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SUGAR

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SANTA CRUZ—A FIELD OF SUGAR CANE

(1463)

Frontispiece

PITMAN'S COMMON COMMODITIES

AND INDUSTRIES

SUGAR

BY THE LATE
GEORGE MARTINEAU, C.B.

SECRETARY TO THE BRITISH SUGAR REFINERS' COMMITTEE, 1872-92
ADVISED TO THE BRITISH DELEGATES AT THE
INTERNATIONAL CONFERENCES OF 1875-6-7, 1888, 1898, AND 1901-2
ASSISTANT BRITISH DELEGATE ON THE PERMANENT INTERNATIONAL
SUGAR COMMISSION AT BRUSSELS, 1903-5

REVISED BY
F. C. EASTICK, M.A.
A I C., F.C.S., HON.F.G.I.

DIRECTOR AND REFINERY MANAGER OF MARTINEAUS, LTD
HON LECTURER AND EXAMINER TO THE INSTITUTE OF GROCERS



SIXTH EDITION

LONDON
SIR ISAAC PITMAN & SONS, LTD
1932

First Edition, February, 1910
Second Edition, November, 1910
Third Edition, August, 1914
Fourth Edition, February, 1918
Fifth Edition, September, 1927
Sixth Edition, January, 1932

SIR ISAAC PITMAN & SONS, LTD.
PARKER STREET, KINGSWAY, LONDON, W.C.2
THE PITMAN PRESS, BATH
THE RIALTO, COLLINS STREET, MELBOURNE
2 WEST 45TH STREET, NEW YORK
SIR ISAAC PITMAN & SONS (CANADA), LTD.
70 BOND STREET, TORONTO

PRINTED IN GREAT BRITAIN
AT THE PITMAN PRESS, BATH

PREFACE

TO THE SIXTH EDITION

OWING to the death of the author in 1919 after 60 years active participation in the Sugar Industry, the reviser endeavoured in the Fifth Edition to record such facts and figures as seemed appropriate in 1927, including the establishment of the Home Grown Beet Industry, a project so consistently advocated by the late author. In the Sixth Edition the outstanding changes recorded are not only the consolidation of the Home Grown Beet Industry and of the Preferential Duties on Empire Sugar, but also the complete cessation of the importation of foreign white sugar, now entirely produced or refined in England, due to the changes effected in the Sugar Duties in 1928.

For those who desire to go more deeply into the interesting study of sugar the following works are of great value : *The World's Cane Sugar Industry, Past and Present*, by Dr. H. C. Prinsen Geerligs, published by Norman Rodger, 2 St. Dunstan's Hill ; *Cane Sugar* (1921), by Noël Deerr, from the same publisher ; also *Beet Sugar Manufacture*, by H. Glassen, published by Chapman & Hall. The *International Sugar Journal* is also essential for all who are interested in sugar, and the reviser acknowledges the use of recent information and statistics contained therein.

He also wishes to express his thanks for the assistance he has received in this work from his colleague, J. H. Lindfield, F.C.S.

F. C. EASTICK

MARTINEAUS REFINERY
LONDON, E.1
January, 1932

PREFACE

TO THE FIRST EDITION

THE publishers have asked me to write a little book on Sugar. I take this to mean a popular book which shall attract the reader by being, if possible, interesting as well as instructive, and that where technical detail is necessary it shall not be too "dry."

But for those whom I may succeed in interesting, and who may desire to know more and go deeper, I can recommend a few books of a reliable character. One of the greatest sugar experts of the present day is Dr. H. C. Prinsen Geerligs, who has been doing splendid work in Java for many years. He wrote a little book in 1902, published at the office of *The Sugar Cane*, Altrincham, on *Cane Sugar and the Process of its Manufacture in Java*, which is easy to read and well worth reading. This was followed by a larger work in 1909, published by Norman Rodger at the same office, entitled *Cane Sugar and its Manufacture*. It does what it professes, giving in one book all that is known of the chemistry and technology of the sugar cane and cane sugar manufacture. The technicalities relating to machinery it leaves to others, especially to Noël Deerr's work, *Sugar and the Sugar Cane*. This book, a very excellent one, published in the same office, appeared in 1905. The most recent work, published by Edward Stanford in 1909, *The Manufacture of Cane Sugar*, by Llewellyn Jones, M.I.E.S., and Frederic I. Scard, F.I.C., is also a fine work, profusely illustrated. A new edition, published by Spon, 1909, has recently appeared, of Newlands' portly and expensive volume, *Sugar: A Handbook for Planters and Refiners*, bringing things

up to date. I hasten to express my acknowledgments to all these authors.

The Sugar Cane, now called *The International Sugar Journal*, published at 2 St. Dunstan's Hill, E.C.3, is the best English vade-mecum for technical matters and general news connected with sugar. *The West India Committee Circular* is also well worth reading, full of interesting news and good pictures. The *Journal des Fabricants de Sucre*, the Paris organ of the French industry, has been one of my constant companions ever since its birth in 1860. It is a mine of accurate information on all matters connected with the world's sugar industry. From America we get the *Louisiana Planter*, *Sugar*, Willett and Gray's *Weekly Statistical Sugar Trade Journal*, and other useful guides to knowledge. There are also German and Austrian sugar journals of a first-class character for those who can read the language. The inquiring student, when he has read and digested the larger works which I have mentioned, can therefore keep up his knowledge from week to week by reading the journals of the day. If this little popular treatise succeeds in impelling him to further study I shall not have laboured in vain.

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SUGAR

CHAPTER I

A RETROSPECT

A POPULAR book about sugar can, perhaps, be made interesting as well as instructive. The dry details of growth, manufacture, distribution, and consumption may here and there be flavoured, illustrated, and developed by a few historical facts. To begin with, a retrospective glance at what the sugar industry was in this country seventy years ago compared with what it is now will best enable the reader to realize at the outset the extraordinary development of the world's sugar industries since the middle of the last century—development not merely in the technical details connected with production and manufacture but also in the much more interesting, because more human, process of keen competition between the various and constantly changing sources of production. This will lead up to a yet higher kind of interest when we come to examine to what extent and in what manner the Governments of various sugar-producing States have stimulated production and influenced, for good or for evil, the natural course of supply and demand. Here will arise many fascinating questions of international relations, political controversies, and the conflict of economic facts with economic theories.

Thus it will be seen, at the end of the story, that the subject of sugar is not only a technical one of the highest importance both from the practical and the scientific points of view, but also has an international, economic

and political side which furnishes a unique and striking object lesson for those who take an intelligent and inquiring interest in the economic questions of the day. But rightly to learn this lesson the reader must bring to the study an open mind, unwarpd by preconceived notions founded on theoretical dogmas unsupported by the practical experience of actual work and daily experiment. In natural science it is necessary to begin in the laboratory in order to arrive at the facts on which to construct theories. In economic science this process is equally necessary, but unfortunately is seldom followed. The history of sugar will show that the practical experience of that great laboratory called industry does not always bear out the conclusions to which learned professors may arrive in the comfortable repose of their armchairs.

To begin at the beginning, let us cast a retrospective glance at sugar in this country seventy years ago, just before great changes began, and first of all to London, at that time the largest centre of importation. The actual figures of proportional imports were, in 1860: London, 50 per cent.; the Clyde, 17 per cent.; Liverpool, 15 per cent.; Bristol, 10 per cent.; other ports, 8 per cent. In the year 1900 the figures, in round numbers, were: London, 11 per cent.; Liverpool, 15 per cent.; the Clyde, 7 per cent.; Bristol, 4 per cent.; other ports—entirely foreign refined sugar—63 per cent. The imports in 1860 were practically all raw sugar; we made all the refined sugar consumed here. In 1900 the imports were, in London, Liverpool, the Clyde and Bristol, raw sugar for refining coupled with a certain proportion of foreign refined sugar. In all the other ports—63 per cent. of the total—they consisted entirely of foreign refined sugar. In 1860 the total imports into the United Kingdom were: raw sugar, 434,766

tons ; refined sugar, 13,303 tons. In 1900 they were : raw sugar, 661,747 tons ; foreign refined sugar, 962,409 tons ; and in 1930, 1,852,264 tons and 59,020 tons respectively. These are eloquent figures and we shall see how the change came about.

In 1860 our supplies of sugar came mainly from our own sugar-producing colonies in the West Indies, Mauritius, and India. The Spanish West Indies, Brazil, and Manilla were our other principal sources of supply. At that time practically all the refined sugar consumed in this country was the product of our own refineries. Sugar refining was, in those days, a most important British industry, and London was its principal centre. In London was produced nearly all the loaf sugar that the country consumed. The London refiners were men of some importance in the City. Their " sugar houses " were to be found in the East End in considerable numbers and constituted the staple industry of the district. From Whitechapel eastward to Mile End, and southward through St. George's-in-the-East to the gates of the London Docks, their chimneys were to be seen on all hands. The London Docks and the East and West India Docks were full of raw sugar destined for these various refineries. A refinery in those days was considered to be a good-sized one if it dealt with three or four hundred tons of raw sugar in a week. This may sound small to the reader of the present day, but he must recollect that the consumption of sugar only amounted then to about 34 lbs. per head of the population, whereas now it is 93 lbs. It must also be remembered that in those days, from the time the raw sugar entered the refinery until it left it in the form of loaf sugar, at least a month elapsed, now it is only a few days.

Some of the London loaf sugar producers were at that time very much in the habit of working almost

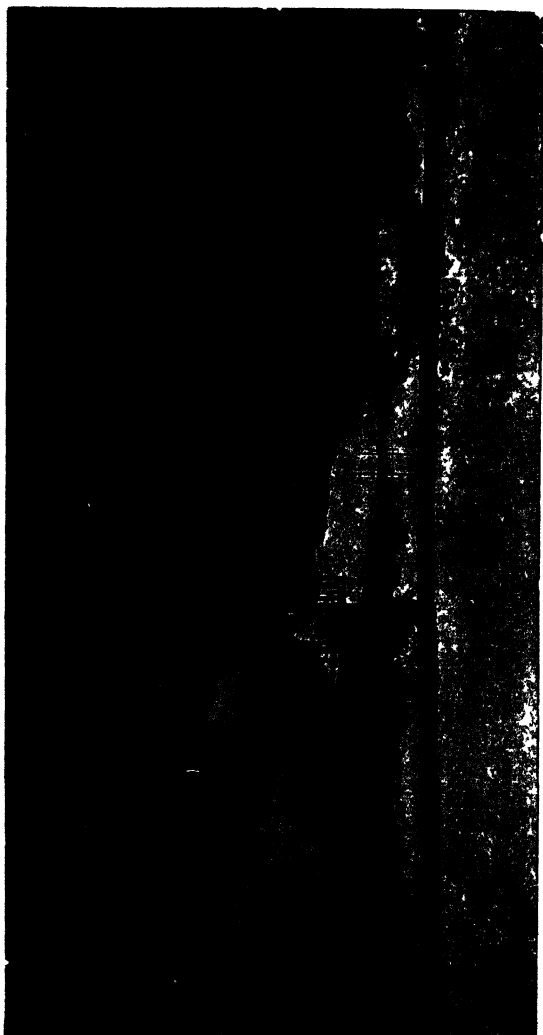
entirely the raw sugar that came from the island of Jamaica. Our West India Islands made only what is called muscovado sugar, the nature of which will be explained when we come to the subject of sugar production. The muscovado sugar from Jamaica was very superior to that from most of the other islands, and was much sought after by the more fastidious of the London refiners. But, of course, the time came, as consumption increased, when the refiner had to add some of the inferior qualities and to maintain his average by using higher grades of raw sugar from Cuba or Mauritius, and subsequently, when the Dutch monopoly of the Java crop ceased, the fine qualities from that favoured island.

In the streets of the East End could be seen, at all hours of the day, great wagons, drawn by the finest specimens of the cart-horse breed, each containing six hogsheads—about five tons—of British West Indian sugar destined for one or another of the twenty flourishing refineries of the district. A visitor to those busy streets, if he followed one of these wagons, would find himself opposite a large factory, a hive of bustling industry. On one side of it would be a row of similar wagons, their freight of raw sugar being hoisted to the top floor of a lofty building where the refining process began. On the opposite side of the works he would find a much longer line of smaller wagons or carts taking delivery of the refined sugar to go to the consumer. Such was the life of the East End in those days.

The London refiner made five products: loaf sugar, white crushed sugar, yellow crushed sugar, and a small quantity of very brown sugar, from which followed the final product—treacle. Even this treacle was a nice sweet food in those days, with a pleasant flavour and aroma of good West Indian sugar.

Passing to Scotland, the next largest seat of the

PENANG—BARGES LOADED WITH CUT SUGAR CANES



industry, there were at Greenock, in 1860, about thirteen refineries, to which must be added four in Glasgow and one in Leith. Many of the Greenock houses were very flourishing and constantly improving their manufacture. The wonderful increase in the raw sugar consumed in the Clyde refineries in the middle of the last century has been stated as follows—

Year	West Indies Tons	East Indies Tons	Mauritius Tons	Foreign Tons	Total Tons
1854 ..	21,483	588	12,045	14,443	48,559
1860 ..	25,962	2,394	10,192	36,539	75,087
1865 ..	30,645	1,000	9,032	95,863	136,540

In the following year, 1866, the total was 162,368 tons.

These figures sufficiently indicate the go-ahead nature of the industry in Scotland at that period. They made no loaf sugar, but supplied the northern (and even the southern) markets with what they wanted, white crystals and white and yellow “crushed” sugars.

Two vital improvements in the art of sugar refining—improvements which created a complete revolution in the industry and in the style of sugar produced—took place during the period indicated in the above figures, and fully accounted for the boom in sugar refining on the Clyde. The first was the adoption of the centrifugal machine, by which the sugar in the boiled crystalline mass is separated from the syrup in a few minutes. The second was the boiling of yellow sugars at a low temperature, causing the sugar to be turned out in a uniformly moist state, and with a pale and delicate primrose tinge instead of a dull dark yellow colour. The firm who discovered and perfected this latter process made a large fortune in less than seven years, and immediately built a big refinery on the banks of the Thames. Here was a striking instance of the often

disregarded maxim, that if you want, in industry, to profit from a new invention you must do it at once.

But the importance of the fact in this particular chapter is that it greatly conduced to the remarkable progress of the industry on the Clyde. The increase already stated was sufficiently striking, but the success continued for twenty years. The yearly average for the five years 1877-81 was 248,429 tons, and for 1882-86 240,852 tons. Then came a terrible relapse. The quinquennial yearly averages which followed were—

1887-91	228,733 tons
1892-96	170,373 „
1897-1900	124,874 „

Thus we see that the first spurt from 75,000 tons in 1860 to 136,000 tons in 1865 reached to 240,000 tons in 1882-86, and then fell away until the average for 1897-1900 was only 125,000 tons, a figure actually lower than that of the first burst more than thirty-five years before. This is almost incredible. Consumption in the United Kingdom had gone up by leaps and bounds, the Greenock refiners had constantly improved their manufacture, their sugar was as popular as ever, and they could certainly work as cheaply as any refiners in the world. This lamentable fall in the Greenock sugar refining industry was entirely the result of the new European bounty-fed competition. British markets, and every small port on the coast, were flooded with foreign refined sugar, sold frequently at prices below the cost of production. After the abolition of the bounties by the Brussels Convention in 1903, the industry recovered, but relapsed seriously through foreign dumping until protected by the Government in 1928.

Let us pass to the next centre of the sugar refining

industry, Liverpool. Here are to be found, even now, some of the oldest names in the trade. Two were well known in the Clyde in the early part of last century. In 1860 there were nine refineries on the Mersey and two at Manchester. They were, like their brethren in London, men of considerable substance and position in the city of Liverpool, who took a leading part in public affairs. Their raw material came largely from Brazil, Liverpool being the principal port for ships from that country. They were, therefore, accustomed to work a rather low class of raw material, and consequently turned out a considerable proportion of yellow sugar. There was one exception to this at a later period—another instance of success in seizing on a new invention rapidly, fearlessly, and on a large scale. There again a large fortune was made in a very few years, and was immediately followed by the erection of a monster refinery on the banks of the Thames, which has flourished greatly ever since, a notable instance of the survival of the fittest. But that does not concern us at the moment. Golden syrup was a speciality at Liverpool, but has now been superseded by a superior article; again, another instance of inventive genius coupled with bold, unhesitating action.

At present there are only three sugar refineries, properly so called, in Liverpool or its neighbourhood, but there are two refineries of sugar for brewing purposes.

Bristol was the fourth sugar refining centre, and historically is the most interesting. In the eighteenth century, Bristol was largely engaged in trade with the British West Indies. There were nearly a hundred firms in the sugar trade, and about twenty refineries in operation. Many of the inhabitants of the town were owners of West Indian estates, and importers of

sugar. Even as late as 1811 sixteen refineries were at work. But when, shortly afterwards, the vacuum pan superseded the older processes the industry became concentrated in fewer hands, and, in 1848, the number had been reduced to five. In 1863 only two remained, afterwards increased to three.

One of these, an old-established firm, was for many years a leading feature of the Bristol sugar refining industry, and carried on the work on a larger scale than any of its competitors in England or Scotland. It was the first to adopt the centrifugal machine on a large scale, and to turn out large-grained crystallized sugar. Of this trade it had for many years almost a monopoly, and a well-deserved celebrity. The family of Finzel were quite the sugar kings of that day, and were as celebrated for their munificent charities as for their fine sugar, of which they turned out more than a thousand tons a week. But, alas, this most successful firm, and their large fortune, disappeared, squeezed out by foreign competition, and by newer schemes and discoveries. The West India sugar, which was the original basis of the Bristol industry, disappeared from the market, and Bristol refiners had to seek their raw material in other and less convenient quarters.

Our brief retrospect of seventy years comes to this. At the beginning of the period we made all our own refined sugar for home consumption. From 1895 to 1913 we imported about 900,000 tons of foreign refined, but managed to produce about 700,000 tons at home. In 1930 we imported 1,852,264 tons of raw sugar but only 59,020 tons of refined. Big refineries have taken the place of small ones. In London, where there were twenty, there are now three, two on the banks of the Thames. But there are also two large refineries and one or two small ones where sugar is refined for the use of brewers.

As to refineries on the Thames, a few words may be not altogether out of place. The first monster building to appear there was built, as has been already stated, about the year 1864 by the Greenock firm who made a rapid fortune by quick and extensive adoption of a new process. The London house was carried on by James Duncan, one of the partners. He was the prince of sugar refiners in his time, and never ceased to keep himself informed of all that was going on in the great beetroot sugar industry of Europe. His enterprise was unbounded, and his success undisputed. The whole region round about the Victoria Docks benefited, not only from the great industry which he established in its midst, but also from his constant munificent, though silent, assistance to all good works in the district. Though he had a beautiful estate on the banks of the Clyde, he was never an idle man. Always at work, always thinking out some new scheme, he soon outdistanced his competitors. At one time he is said to have turned out two thousand tons a week. But when the crisis of 1884 arrived, with all its disasters, he had a hard struggle and, in 1886, his great works at Clyde wharf, Victoria Docks, were closed and sold to Martineaus, who had produced loaf sugar since about 1790. This refinery was later destroyed by fire, which ended the production of loaf sugar in this country. He was for years Chairman of the British Sugar Refiners' Committee during their long fight against unfair foreign competition.

Then came another man, the late Sir Henry Tate, who made a rapid fortune by quick and bold adoption of a new process. While others talked he acted. He was lucky in one respect. He came to London in 1877 to make cube sugar, just at the moment when the French Government, goaded by our persistent exposure of the vast profits made by Paris refiners



REAPING SUGAR_CANES IN THE WEST INDIES

out of the sugar duty, at last abolished the questionable practices and set matters on a more even footing.

In Scotland, where there were eighteen refineries, there are now three, with one for brewers' sugar. Lancashire, which had eleven refineries in 1860, now has three, together with one or two makers of brewers' sugar. Bristol is now a blank.

These great changes are the result of many causes, some natural and inevitable, others artificial, injurious both to our industries and to our consumers, and not only much to be deprecated, but also, curiously enough, easy to overcome. And yet they were permitted, for more than thirty years, to create such a disturbance of the natural course of production throughout the world. The history of this part of our subject will come at a later stage, and we must now plunge into the more technical details of sugar production.

CHAPTER II

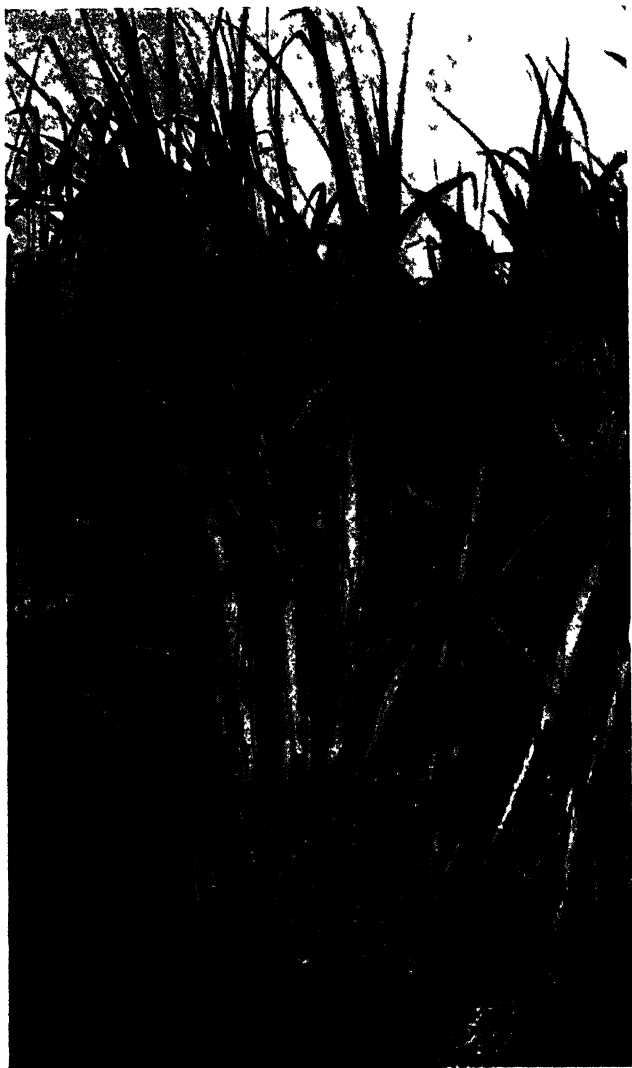
SUGAR CANE AND SUGAR BEETROOT

IMAGINE a great thicket of sugar cane in the full vigour of growth before it is ripe. Stems six to twelve—even to twenty—feet high, clothed from head to foot with great tropical leaves, and crowned at the top with a final wide-spreading bunch of the same. Imagine the field again when the canes are ripe. Except the bunch at the top the leaves are gone. The slender elegant cane, of various hues, curves up to the sky, shining in its waxen skin, variegated with rings at regular intervals where the lost leaves had sprung out, and where still nestles the bud or germ which under wild conditions would, when the cane falls exhausted, throw out roots and spring into a new cane. From the bunch of leaves at the top has now shot out a long slender arrow with silky grey tassels of feathery flower at the end of it. The cane is ripe, and full of good sugar juice nearly up to the top. It is cut down, the top joints removed, and the rest of the cane piled up on wagons to go with all speed to the factory. No time must be lost, for the sugar begins to deteriorate with great rapidity.

In the good old days, when fortunes were made out of sugar without much trouble, there was plenty of loss before the cane got to the mill, and plenty more after it got there. But now all this is changed. There is little hope of making a decent living unless everything is done in the best way; and this “best way” it has taken many long years and much science, skill and perseverance to discover and carry out. The Indian

native, the Chinaman in Formosa, or the inhabitants of the Philippine Islands may still be squeezing out the juice with primitive rollers, boiling it in iron pots till it solidifies, and then selling it for what it will fetch, but this is not sufficient to supply the world with nineteen million tons of cane sugar every year. The growing of the cane and the making of the sugar have now become industries of the very highest scientific perfection. Accurate chemical knowledge of the constituents of the cane, of the constituents of the soil where it happens to be growing and, consequently, of the nature of the manures necessary to maintain in the soil the various foods required for the healthy growth of the plant, are the first requisites for the successful cane farmer. He must also know which particular kind of cane—for there are many—is most likely to flourish in his soil and climate. As to cultivation, the ordinary rules for good ploughing, good drainage, and careful hoeing during the early growth, are just as imperative in the tropics as in the European fields of sugar beet or any other crop.

The sugar cane is planted, not sown. A piece of cane long enough to include two or three of the rings, is laid lengthways, or stuck in in a slanting direction, along a furrow running the length of the field, or in holes dug at regular intervals. When the trench is planted the pieces of cane are lightly covered with earth. In a few weeks they show growth above ground. The germ-bud at the ring has begun to shoot out into young cane, and the ring at the same time has thrown out rootlets into the soil. The parallel trenches must leave room between them to enable the labourers, when the wide-spreading canes, double the height of a man, are getting ripe, to reach between the rows and remove the dying leaves which cumber the ripening



By permission of the

Queensland Government

THE SUGAR CANE

cane. The falling leaves take with them much valuable food to return to the soil, and the naked cane has better opportunity for good ripening.

The exact time when the cane is ripe must be accurately judged. If the cane is cut before it is quite ripe some of the sugar which it contains is not in a crystallizable state. On the other hand, if the cane gets too ripe some of its crystallizable sugar goes back into the uncrystallizable state. This must often be a sad trouble to the manager of an estate and factory. Again, if the central factory is supplied with canes from a multitude of small farmers they may be all wanting to send their canes in at one time. To the factory this is an impossible situation. The manager must, consequently, be content to have canes which are not always at the exact point of ripeness which might be desired.

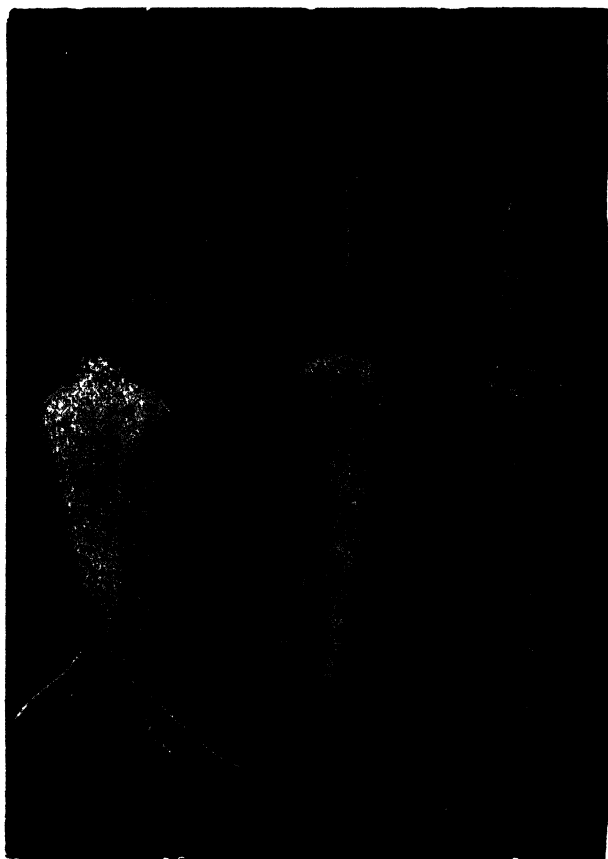
The growth of the cane, lasting about 15 to 18 months is an interesting study. When it is at maturity the rind is of a very strong consistency, and is protected on the outside by a waxen covering. The inside of the cane consists of the cells containing the sugar juice, and of long bundles of fibres which convey from the ground the water and food necessary for helping to carry on the process of development. These fibres call at each ring of the cane in order to deliver the particular food required for the growth of the leaf, and the sustenance of the germ-bud. To the top of the cane they bring those things which are necessary for the growth of the cane, the arrow and the flower. The leaves in their turn do a most important work. While the internal fibres are bringing food and water from the ground, the leaves, helped by the sunshine, are collecting carbonic acid from the air, and it is the carbon thus consumed by the plant which, combining with the water from below, forms the substance which we call sugar.

It is the same with the sugar-beet, that little modest plant of northern climes, with its small bunch of leaves close to the ground, spreading out like a toy parasol to keep the ground moist underneath, and to suck in the rays of sunshine from above. It is a little bulging root, tapering to a slender tap-root which thrusts its way far down to find water and food, while the leaves and the sunshine make the sugar. It is curious to think that this humble root, weighing only two pounds, at one time gave to the world as much sugar every year as the lordly sugar cane, and that the beetroot factory should actually extract a greater percentage of sugar from the little root than the cane factory wins from the rich cane. But it must not be forgotten that, under favourable circumstances, the cane can produce twice as much sugar to the acre as the beetroot.

Up to 1903 the beetroot had the great artificial stimulus and assistance of paternal Governments. In some places the cane now receives something of the same kind. The United States gives preferential treatment to Cuban sugar, and Cuba consequently has gone ahead by leaps and bounds. But the United States does more than this. Its own sugar, from the cane fields of Louisiana and the beet fields of the Northern States, is free of duty. Those industries therefore flourish. It also admits, free of duty, the cane sugar from Porto Rico, Hawaii, and the Philippines. The two former have consequently doubled and trebled their production. It remains to be seen what the slow moving inhabitants of the Philippines will do. Japan has also come into the field as a paternal Government. Their island of Formosa always produced sugar in the Chinese way. Bad canes, badly cultivated and crushed in stone mills driven by buffaloes, produced a rough, dirty, nearly black sugar, and the Chinaman was satisfied. He obtained less than

half the juice from the cane, and half the sugar from the juice. But Japan substituted for this state of things a first-class sugar industry, and set about it, as usual with the Japanese, in a business-like way. They began by learning their lesson and finding out how sugar is grown and how it is made in the very best factories, whether tropical or European. They then told the people in Formosa how they should grow their canes, what canes they should plant, and what manure they should use. They told them, further, that central factories would be established which would buy the improved canes from the farmers at a much better price than what they got out of their whole process of growing and sugar-making. It took some time to move the naturally conservative ideas of the native producer, but they succeeded. Factories are being erected and the growers are beginning to fall in with the new ideas, and in a few years Japan will make sugar enough to supply the Japanese consumer with all the sugar he wants; and as the sugar receives preferential treatment in Japan, and therefore fetches a high price, there will be a great stimulus to Formosan production, and the final result may very likely be that Japan will become an exporter of refined sugar. In 1901-2, Formosan exports to Japan were 46,893 tons; in 1910-11, 256,950 tons. The crop in 1931-32 in both countries totals 920,000 tons.

The methods of growing cane sugar vary in different countries. In our West Indian colonies the first planting may give an average yield of thirty tons of canes to the acre. This is called the plant-cane crop. The "stool" left when the canes are cut down will, if permitted, throw out another but inferior crop of canes. This is called the "ratoon" crop, and may amount to about twenty tons of canes to the acre. In the West



BEETROOTS

Indies, and in other parts, several ratoon crops are sometimes grown; but in countries like Java, where labour is plentiful and cheap, the crop is freshly planted every year. In Java, sugar is, in fact, a rotation crop, other crops being grown in alternate years. This is a governmental regulation which must be observed. This system, coupled with great perfection in cultivation and manufacture, has had the result of realizing, as the average crop for the whole of Java, the almost incredible quantity of more than four tons of sugar to the acre. This means that many of the best estates and factories turn out at least five tons to the acre, a truly marvellous performance when we recollect what was considered a good yield in the West Indies fifty years ago. Two hogsheads of muscovado sugar to the acre was considered in those days a thing to boast about. As a hogshead weighed from sixteen to eighteen hundredweight this was only a yield of a ton and a half to the acre, about the average yield of the European beetroot.

There is another important variation in the agricultural system of different cane sugar countries. The sugar cane must have water, if it is to grow properly and give its customary yield. Very often it gets too much water and, therefore, good drainage is essential. In British Guiana, where the cane fields lie below the level of the sea, the superfluity of water has sometimes to be pumped off the land. But, on the other hand, there is often a terrible spell of dry, hot weather, and then water has to be pumped on to the land. Many countries have to grow their canes almost entirely by irrigation. Peru is the most remarkable case, for in that country there is practically no rain. Fortunately there are splendid means for easy and effectual irrigation. Where this is the case some of the heaviest crops in the

world are produced under a system of thoroughly scientific irrigation. In Hawaii, for instance, it is known, and has been recorded, that crops of more than fifty tons of cane to the acre have been produced. Here we have the wonderful crops of Java easily eclipsed.

There is one more detail about the sugar cane which must be noted. The wild cane produces seed, but the cultivated variety has become so accustomed to growing from cuttings that it has, as a rule, forgotten how to produce seed. It was discovered in 1888 that seed is formed and that it will produce canes. These seedling canes come up in very various qualities, some perhaps better than the existing kinds. Scientists set to work to select from these seedlings and obtained canes that possess a maximum of good qualities, each selection the one most suitable to a particular soil and climate, and, especially, the one most powerful in resisting disease. The growers of cane sugar have thus at last found an opportunity of following the example of the beetroot industry.

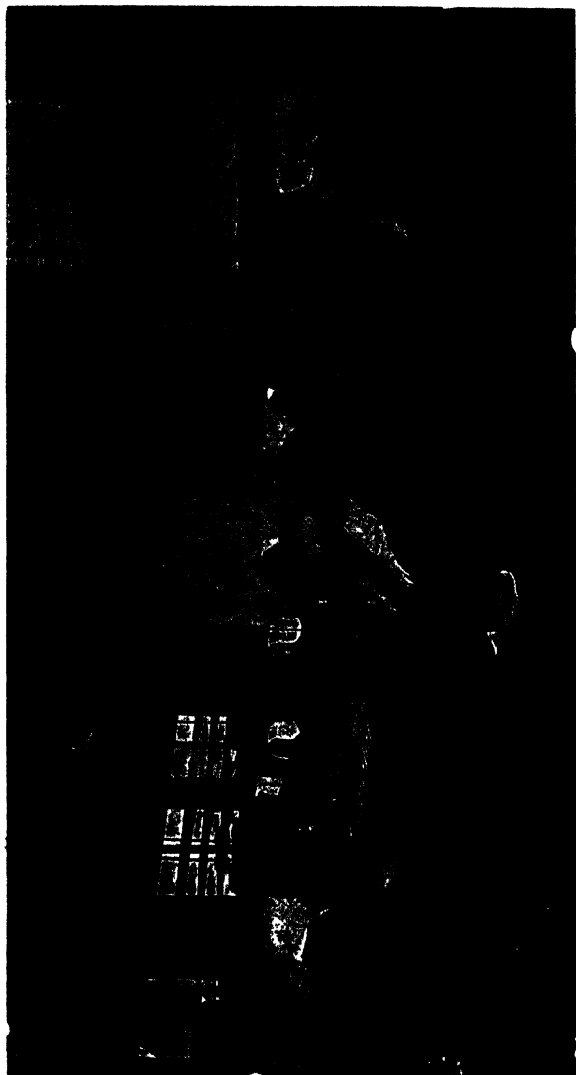
The cane crop fortunately takes place at very various times in different quarters of the tropical regions, and thus does not flood the markets of the world with all its sugar at once. Cuba, stimulated by the United States preference, now makes 3,000,000 tons of sugar a year. As it naturally sent its sugar to the market where at one time it enjoyed a preference of about 1s. 3d. per cwt., the American markets were flooded with Cuban sugar during the crop season. This led to the curious and abnormal fact that in the early months of the year the price of sugar in America was often 1s. 3d. per cwt., and even more, below what is called the world's price. The preference now is about 1s. 8d., being 20 per cent. of the current duty.

It may be interesting to note the dates at which the

various crops of cane sugar begin. All the West India islands begin in January, except Cuba, which is a month earlier. In the United States the cane sugar districts of Louisiana and Texas begin in September. Mexico, like Cuba, also begins in December. In South America, British Guiana has two crops, May and October, while the Argentine gets to work in June. In the East, Java, a most important crop, begins in May; Formosa and the Philippines in December, and British India about the same time. Egypt works in January, and Mauritius in August. August is also the crop time in Natal. In Australia and the Fiji Islands June is the month.

In the European beetroot countries the process of selection has been going on for generations. The roots used to yield 5 to 6 per cent. of sugar; now they yield 13 to 17 per cent. In 1908, a very exceptional season, the average yield for the whole of Germany was nearly 17 per cent., and for Czechoslovakia even more. This is a truly wonderful advance, thanks entirely to the producers of beetroot seed. By constantly selecting the richest roots for planting in their seed nurseries they have gradually advanced year by year to this pitch of perfection. The beetroot flowers and seeds in its second year, so there is every opportunity for this process of selection.

The beetroot plant is sown as early as possible, but not so soon as to run the risk of late frosts. The ground is prepared in the most thorough and scientific way because the crop, to be successful, must have clean land, well broken up, and in good heart as to the right kind of richness. To keep it clean during the growth of the young plant you may see, on a first-class farm, a band of labourers hoeing between the faint green lines of baby plants long before weeds are visible. This



LABORATORY FOR TESTING BEETROOTS FOR SEED-SELECTION PURPOSES

is the real way to stop weeds. The germs are turned up and left to die in the hot sun of May and June. If the crop has a nice moist spring, plenty of sunshine in the summer, and a good long autumn, it will be a good one. A dry spring, wet summer, and short, cold autumn, will give a short crop, but worst of all is drought all through spring and summer.

The roots begin to be ready for the harvest in late September and early October, and they are all gathered in by the middle of November. Those that do not go direct to the factory, have to be pitted till the factory is ready for them. The pit is constructed in a scientific way, with proper ventilation, and a good covering. But the factories are so big now that they make short work of it, and have generally finished with their roots by the end of the year. The delivery of the roots to the factory was at one time a sad source of disputes and friction, but habit has pretty well overcome this difficulty. The farmers and the factory now understand each other better. The farmer is bound by contract to use the best seed, and the right kinds of manure, and to deliver the roots clean and well trimmed. If Germany in a good year can make an average yield of nearly 17 per cent. of sugar, it is certain that nothing but first-class roots have been delivered. The weight of roots to the acre varies in different countries. Germany averages between 10 and 14 tons, Austria much less. Russia cannot get beyond 6 to 7 tons.

There are sugars other than the products of the cane and the beetroot, and they must not be forgotten. The most important came from India, and is called "Palmyra Jaggery." At one time this country used to import appreciable quantities, and its production is a considerable industry in India. The juice is tapped at the top of the tall palm-tree and caught in earthen pots suspended

from a grooved stick, which directs the flow of juice into a receptacle. The tapping of the juice is often incorrectly described ; there is no incision in the bark, the long flower is tied up and a piece cut off at the top. The pot is tied on, and juice flows into it from the wound. It is cut again when the juice ceases to flow, and so on from day to day. The pots are collected each day and the juice boiled down to the crystallizing point.

Another tree that produces sugar is the sugar maple of America. Here the juice is really tapped from the stem and boiled down into sugar. The quantity annually consumed in America is about 11,000 tons.

CHAPTER III

MILLING THE CANE

WE now begin the main part of our subject, the extraction of the sugar from the cane or the beetroot. With the cane the object is to get the juice out of it with all speed and to get as much of that juice as possible. In early days—or even now in primitive countries—the cane was crushed between two vertical rollers of wood or stone, driven by bullocks or by hand. By this method they did not get half the juice, but the remains of the cane made good fuel for boiling the juice. In course of time iron rollers were substituted for wood and stone, and were set horizontally. The driving power for this more powerful mill was wind or water, as in the case of the old flour mill. The island of Barbadoes is not, like its neighbours, mountainous, and is, therefore, well suited to the use of windmills, especially as it has a fairly breezy climate. Many of these windmills may still be seen driving the sugar mills in that fertile, industrious, successful, and well-populated little colony.

But a great revolution has taken place in most tropical sugar-producing regions. Extended cultivation soon required new implements capable of dealing with large quantities of cane in an expeditious and economical way. The three-roller mill, driven by steam power, soon became the rule. This machine consists of two rollers placed side by side but with a space between, and another above them nearly touching them. The engine drives gearing which reduces and regulates the speed of the three rollers to the required pace. The lower rollers revolve in the same direction, the upper one in the opposite direction. A travelling band or “carrier”

conveys the canes to the mouth of the mill, care being taken that they are so evenly distributed as to form a constant and uniform feed. The canes enter between the front roller and the upper one, only just enough space being left between the two rollers to permit them to catch hold of the canes, and draw them through. Between the two lower rollers, just below the centre of the upper roller, is a metal plate which causes the crushed cane to turn towards the space between the back roller and the upper one, where it is again drawn in and crushed a second time. These two rollers are placed much closer together, because the already partially crushed cane can now be forced through a narrower entrance. This double crushing may, if well done in a sufficiently powerful mill, extract 60 per cent. of the juice in the cane. This had to be improved upon if cane was to compete with beetroot. The arrangement now is a combination of three of these three-roller mills set tandem fashion, with carriers to convey the crushed cane from the first to the second and from the second to the third. It might be imagined that when the crushed cane, called megass—or, in French, *bagasse*—issues from the third mill it has lost all its juice. Unfortunately, this is not so, and therefore other expedients have been adopted to still further reduce the quantity of sugar left in the megass. The rollers in the second and third mill are placed closer together in order more completely to squeeze the now attenuated strips of crushed cane. Those mills are also driven at a slightly slower speed. But important additions have of late years been made. It was found that the first of the two crushings in the front mill did not do much more than break the outside rind of the cane, and that a larger quantity of cane could be worked with the same power if the cane could be cut or torn up to a certain

extent before entering the first rollers. Cane cutters or "shredders" were therefore, introduced in front of the triple arrangement of mills. Another and perhaps better contrivance was afterwards adopted, a pair of rollers with V-shaped corrugations, which slightly break the canes, and thus enable them to be more thoroughly and quickly crushed in the first mill.

But still there was too much sugar left in the final megass. The next scheme, therefore, was to pour water on the carriers between the first and second, and the second and third mills. This water, if properly sucked up by the megass, dilutes the juice and, therefore, the juice in the final megass, being thus diluted, contains less sugar. Dilution of the juice is, of course, objectionable, because it involves the consumption of more fuel in the subsequent evaporation. Very careful calculations are, therefore, necessary, based on the value of sugar and the cost of fuel, in order to arrive at the point where saving of sugar costs more than the value of the sugar saved. To reduce the dilution as much as possible it is now customary to use the diluted juice from the last mill to wash—"macerate" it is called—the megass on its way from the first to the second mill. A careful note of the density—specific gravity, tested by the hydrometer—is taken at the last mill in order to maintain uniformity of maceration, and to make sure that the dilution does not exceed the calculated maximum to be permitted.

The exhausted megass goes straight to the boiler-house for fuel. The great improvement in special boiler furnaces for the consumption of megass now generally enables cane sugar factories to raise all the large quantities of steam required for evaporation and driving without the use of any other fuel—a great advantage for cane over beet.



JAVA—A MODERN SUGAR-CANE MILL

The juice is caught in a trough below the mills and flows to a vessel where it is roughly strained from the finely divided cane fibre which falls down with it, and is then pumped up to the clarifiers.

Cane juice is a substance of somewhat complex character. The juice from the first mill is comparatively pure, limpid and of a light colour. But the continued crushing in the second and third mills brings more impurities into it. The colouring matter from the rind of the cane gets into it; so do the organic salts, gums, and colloids, all of which make it more and more viscous and quite impossible to filter or evaporate without previous and complete clarification, a matter for consideration in a following chapter.

A combination of crushing the sugar cane in the usual way and then treating the megass in a diffusion battery, called the *Naudet* process, attracted some attention. Sixty-five per cent. of the juice is first extracted in the mill, and the megass is then loaded into the diffusion battery. The juice, heated and mixed with lime as if it were going to the clarifiers, is then poured on to the megass, and transferred from vessel to vessel as in the diffusion process. This process dispenses with the elaborate clarifying and filtering operations, but has not been adopted.

A good ripe sugar cane contains, on the average, about 75 per cent. of water, 12 to 15 per cent. of crystallizable sugar, 1 to 1½ per cent. of uncrystallizable sugar, 10 per cent. of fibre, less than 1 per cent. of incombustible matter—called “ash”—and less than 1 per cent. of organic acids, gums, and albumen. The ash consists of very varying proportions, according to the nature of the soil and of the manures, of silica, potash, lime, magnesia and soda, mentioned in the order of their importance, silica and potash being the main ingredients. The silica

exists mostly in the form of silicates of an alkaline base. The alkaline bases, mostly potash, are also in combination with organic acids, which disappear on incineration, or with phosphoric and sulphuric acid, and chlorine, all of which constitute part of the ash.

It is now necessary, before going further, to explain the nature of the three kinds of sugar contained in the sugar cane, one crystallizable and two called "uncrystallizable." These are only rough and ready expressions for which more accurate words have now been substituted. But an explanation of the difference between the three kinds of sugar, and of their proper names, requires a brief preliminary description of the way in which the quantity of these sugars in cane juice, or any other sugar solution, is determined.

The polarimeter is an interesting instrument, and its use in every sugar factory or refinery, and also in every commercial transaction in raw sugar, is now universal and essential. Its construction is based on two facts. The first is that when light passes through certain crystals, calc spar for instance, the light is divided, if the crystal be properly adjusted, into two rays, one of which has become "polarized." This means that the light ceases to be diffused equally in all directions, but is only visible in one plane. The second fact is that if this ray of polarized light be passed through a solution of crystallizable sugar its plane will be deflected to the right.

The object of the polarimeter is to measure the extent of this deflection, and thus detect the quantity of sugar contained in the solution, a very ingenious and complicated process. The general facts can, perhaps, be given without too many technicalities. If light were made to pass through a properly adjusted crystal and thus be converted into a polarized ray, and if this

ray were then intercepted by another similar crystal, similarly adjusted, the polarized ray would pass freely through the second crystal. But if, a tube were inserted between the two crystals, containing a solution of sugar the light would no longer pass through the second crystal because the plane of the ray would have been deflected by the sugar. The second crystal would have to be turned until it arrived at the angle to which the ray had been deflected. When the light fully reappeared, the angle through which the crystal had been turned would indicate the amount of deflection. An instrument could be devised in which the scale would be so adjusted, and the parts so constructed that the zero should be the point where, with pure water in the tube, the two crystals coincide and the light passes through; and the one hundred point would be that to which, with a fixed weight of pure sugar dissolved in a fixed volume of water in the tube, the crystal would exactly transmit the full light of the deflected ray. In practice, it is necessary to adopt a more complicated arrangement in order to secure accuracy. Between the tube and the second crystal is inserted a "compensator," constructed of two wedge-shaped crystals, which can be moved across each other by means of a screw until they exactly compensate or neutralize the deflection caused by the sugar, and allow the ray once more to pass through the second crystal. The screw at the same time moves a vernier scale on which the operator can read off the percentage of sugar contained in the sample. But this does not give absolute accuracy because the exact point of maximum light or maximum darkness is difficult to detect. Behind the polarizing crystal, between it and the tube, is therefore inserted a plate of quartz, made of two plates joined together side by side, with their axes opposed,

the one from right to left and the other from left to right, the join being a perpendicular line in the centre. When the ray is not deflected, the eye of the operator sees a field of uniform colour. But when the ray is deflected by the sugar he sees the field divided by a sharp perpendicular line into two different colours. As he moves the compensator the colours become more uniform, and when an absolute uniformity of colour has been restored he reads off on the scale the percentage of sugar. This method gives great accuracy, but the instrument has now been superseded by one in which shadow is substituted for colour, which is still more accurate.

The quantity of crystallizable sugar is thus accurately determined in the laboratory. The other varieties of sugar, called uncrystallizable, have an avidity for oxygen; their quantity is therefore determined by measuring the quantity of a standardized solution of oxide of copper (cupric oxide) which is "reduced" by the sugar solution to the insoluble form of cuprous oxide, which contains less oxygen. The uncrystallizable sugars are therefore called "reducing sugars." They generally exist in the form of equal quantities of dextrose and levulose, which mixture is created by the action of acid and heat on the crystallizable sugar, which is called sucrose. This mixture is called "invert sugar" because it deflects the polarized ray to the left instead of to the right.

But dextrose and levulose also exist separately in varying small quantities in the sugar cane. Dextrose is so called because it deflects the ray to the right, but not so much as sucrose. Levulose is so called because it largely deflects the ray to the left. Dextrose is produced in large quantities for industrial purposes by the action of acid on the starch contained in grain, and is called

glucose. Maize is generally used for the purpose, and the United States is the largest producer. In that form it is a water-white viscous substance with a sickly-sweetish taste. It is also produced in a solid form. Levulose is also called fructose or fruit sugar. It does not appear in sound ripe canes, but can be found in unripe or over-ripe ones. Dextrose exists in both ripe and unripe cane, and is also found in many other plants. But the existence of dextrose and levulose as separate substances is very small compared with the quantity produced by the decomposition of sucrose into "invert sugar." This is the "brewers' sugar" of commerce which, if very pure, has the appearance and flavour of honey, the latter being a natural form of invert sugar. Golden syrup is an accurately proportioned mixture of sucrose and invert sugar.

All these sugars are called "carbo-hydrates" because they consist of carbon combined with hydrogen and oxygen in the proportions in which those two elements exist in water. They are formed by the tissues of the leaves of the sugar cane, under the influence of the light of the sun, combining the water of the plant with the carbonic acid of the atmosphere. The stronger the light the more rapid the process. Sucrose is created and conveyed to the stalk. If the process is too rapid during the daytime starch is stored up, and this in the night season is converted into dextrose. Part of the sucrose may also be inverted and thus a little levulose added to the dextrose. The respiration of the plant requires these "reducing sugars," converting them back to water and carbonic acid. Some of the sugars are conveyed to the green top of the growing plant, and further inversion takes place to assist the vigorous growth by vigorous respiration. The reducing sugars also assist in the formation of the

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fibre of the cane, and some of them combine with nitrogenous substances to form albuminous matter. As the plant ripens and the leaves begin to fall the vigorous respiration slackens, less reducing sugar is required, and the sucrose is stored up in the cells of the pith of the cane. A growing cane, therefore, contains much reducing sugar—or invert sugar—used for growing purposes, while a ripe cane contains sucrose with a very small admixture of invert sugars. When the lower leaves die the sucrose is increased only from the action of the leaves which remain at the top, and the time comes when there is no further increase. That is the point of ripeness. After that the heat of the sun has no further creative effect, but would, if the cane were not cut, begin, with the help of the acids in the cane, to convert sucrose into invert sugar.

The constituents of the cane juice as it flows from the mill are approximately known, but of course they vary greatly according to the quality of the cane, which also varies in different countries and soils. The variation also arises from the state of ripeness of the cane. The following are figures of the analysis of cane juice which has rather more uncrystallizable sugar than it ought to have if it were perfectly ripe, but they suffice to indicate the proportions of the various constituents of the juice. They also illustrate the impurity of the juice from the second mill as compared with that from the first. They are taken from Prinsen Geerligs' smaller work on cane sugar, published at the office of the *International Sugar Journal*, London.

Sucrose, 16.49 per cent.; glucose, 1.98; ash, 0.28; gums, 0.125; albumen, 0.025; free acid, 0.048. The density by the Brix hydrometer was 19.2. This hydrometer indicates the total quantity of dry substance in solution. The quantity of sucrose, per cent. of total

dry substance, is, therefore, 85.9. This is called "the quotient of purity," and is the analysis of the juice as it flowed from the first mill. That of the juice, without maceration, as it flowed from the second mill gave the following results. About the same sucrose, rather less glucose, ash increased to 0.41. Gums increased to 0.346, just three times as much. Colloids increased to 0.092, nearly four times as much. Free acid increased to 0.072. Quotient of purity reduced to 84.4. The reason why the glucose was less is because the top part of the cane, which contains the largest amount of glucose, and which is the softest part, had been more thoroughly squeezed by the first mill than the harder parts of the cane. The third mill gave a purity quotient of 84. The colour of the juice from the first mill was light, from the second dark, from the third very dark. The word glucose is here applied to all reducing sugars or invert sugars.

CHAPTER IV

EXTRACTING BEET JUICE

FORTUNATELY for the producer of beetroot sugar, his raw material, the root, will keep fairly well, so he is able to make sure of a constant and sufficient supply from the day he begins work until his last load of roots comes in. This is of immense advantage in the working of such a delicate article as sugar juice. Interruption of work is most undesirable, but it must sometimes happen in the case of the sugar cane.

The roots have to be delivered to the factory as free as possible from soil or stones, and thoroughly trimmed from leaves and rootlets. They are tipped from the road or rail wagons into flumes or troughs from which they are carried by running water into the factory to the washing machine, where they are completely cleansed. They are then elevated to the weighing machine, as the manufacturer must know the exact weight of the roots he works, and this information is also necessary for Excise and statistical purposes in some countries.

Then comes the extraction of the juice. Seventy years ago this was done by tearing the roots into pulp in a powerful machine, and then squeezing the juice out of the pulp by hydraulic pressure. It was an interesting process to watch. The number of hands it employed was remarkable. There was a constant rushing about of people in a hurry; first to fold up the pulp in cloths and place it on the trays to go to the press; then the carrying of these trays and adjusting them, one above another, on the press. And while this was going on an opposite gang was as busy removing

the pressed pulp from another press, disposing of the pressed cake of valuable cattle food, and running for more pulp to recharge the second press. And so on for all the row of presses.

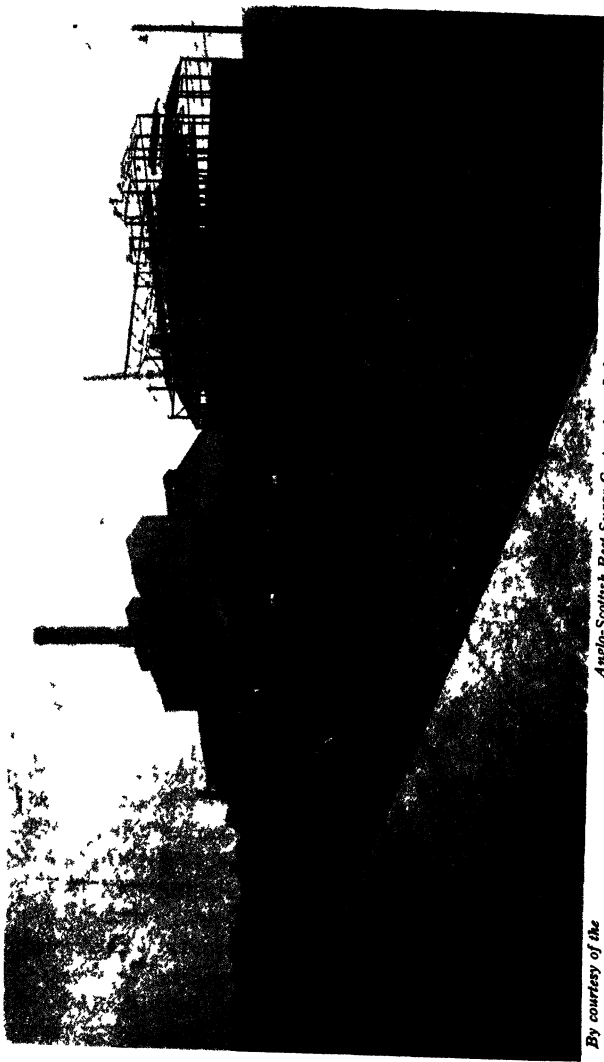
The trouble and expense of this method of work soon led to the invention of various kinds of continuous presses, which did the work without all this expenditure of labour and loss of time. Some of these presses did their duty fairly well, and were regarded at the time as the height of perfection.

But a great revolution was approaching. In the year 1860, Julius Robert, sugar manufacturer at Séelowitz in Austria, successfully put into practical form an entirely new method of extracting the juice from the beetroot, called the Diffusion process. His success was complete. All the sugar factories in Germany and Austria gradually adopted it, and in little more than ten years its use had become universal in those two countries. In some parts of a beetroot factory of to-day, instead of pandemonium you would find almost silence. You begin to wonder where the workmen are, and where is the sugar juice. You see a vast room, full of tall cylindrical vessels controlled at the top by a complicated system of valves. You hear, indeed, one machine making a slight noise on an upper floor, but you see no one until, perhaps, a solitary man begins to manipulate one or two of the valves. That is the only sign of life which you can, at the first glance, detect in that very important wing of the establishment.

This process of Diffusion is so interesting, and has had such an important bearing on the success of the industry, that it must be described in some detail. It was found, some seventy years ago, that when two liquids of different densities are separated by a

membranous partition a process of diffusion takes place, the denser passing into the lighter, and the lighter into the denser liquid. This occurs in spite of the fact that the membrane is not a filtering medium. It was also found that if the denser liquid contained in solution a mixture of crystallizable and uncrystallizable colloidal substances, the former would diffuse freely into the lighter liquid, while the uncrystallizable would hardly diffuse at all. This phenomenon was called osmosis, or osmose. The diffusion of the crystallizable substances into the lighter liquid was called exosmose, and that of the lighter into the heavier liquid, endosmose. The easily diffusing substances were called crystalloids, and the others, such as gum, albumen, gelatine or glue (*colle*) were called colloids. If, therefore, there should be on one side of the membrane a quantity of the juice of the beetroot or the cane, containing crystallizable sugar mingled with many gummy and gelatinous substances, and on the other side water, the solution of sugar would diffuse into the water, and the water into the sugar juice until the liquids on each side of the membrane became of the same density. If the water containing the sugar were then drawn off and fresh water substituted the diffusion would recommence, and this process might be continued until the whole of the sugar had passed away in the form of a nearly pure solution, while the impurities would remain alone in the solution which was originally sugar juice. The membrane may be animal or vegetable—parchment paper, for instance, answers the purpose.

But in nature the walls of the cells of plants form a diffusing medium. The sugar in the beetroot or the cane exists shut up inside the cells. It was found that it could be extracted in the way described above, by diffusion.



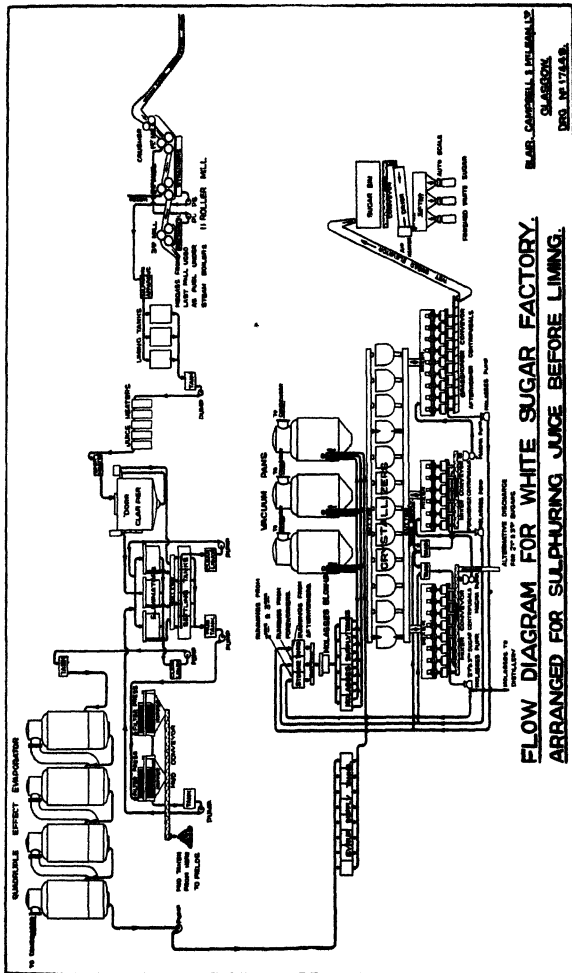
By courtesy of the

Anglo-Scottish Beet Sugar Corporation, Ltd., and Messrs Duncan Stewart, Ltd., Glasgow

COLWICK FACTORY, WITH BEET FLUMES AND REFTS

The plant for doing so is constructed and worked in the following way. A number of large vertical cylindrical vessels are ranged either in rows or in a circle. They are furnished with a well secured man-hole at the top and bottom, and with pipes which convey hot water to each vessel, and others which convey the liquid from each vessel to its next door neighbour, passing on their way through a heater which keeps the liquid up to a temperature of 170° F. The pipes are arranged so that the liquid can be passed from one vessel to another either at the top or the bottom, or can be drawn off when the process of diffusion is completed. On the floor which commands the top of this battery of vessels are the valves by which the man in charge is able to conduct the operations. On an upper floor is the machine which cuts the roots into slices, all of the same size and shape, so that they can lie in the vessels without getting jammed together, but leaving room for the water to flow freely round them. If the battery is arranged in a circle the slices from above can be directed by a revolving shoot into any one of the vessels. On the upper floor is also the hot-water tank, situated sufficiently high to give the necessary pressure for the circulation of the liquid through the vessels of the diffusion battery.

Let us suppose that all the vessels (8, 12, 14 or 16, as the case may be) are filled with slices, and the openings at the top through which the slices have been shot securely closed. Hot water from above is then turned on to the first vessel until it is full. Diffusion of the sugar takes place, and the density inside and outside the cells begins to approach uniformity. Before the diffusion seriously slackens its pace the water—now a weak solution of sugar—is passed on to the second vessel, after traversing the intermediate heater, and



Messrs Blair, Campbell & McLean, Ltd, Glasgow

meets with fresh slices. Here the density of the juice in the cells exceeds that of the weak sugar solution, and diffusion goes on briskly. The process is continued through about nine vessels. The solution of sugar when it has travelled so far is so nearly of the same density as the juice in the cells, that diffusion practically ceases. The sugar solution—called diffusion juice—is, therefore, drawn off, and goes to a measuring tank, and thence to the clarifiers to commence the defecation process. We now have nine vessels of the diffusion battery of which it may be said roughly that in the first the slices have lost all their sugar, in the second they may have lost about 90 %, and so on, up to the ninth, where very little sugar has been diffused out.

After the weak sugar solution leaves the first vessel, hot water is turned on the second, and follows round. A fresh exhaustion of the slices results. The process will finish at the tenth vessel, and again the contents of a cell of diffusion juice will be measured and go to the defecation. We can imagine the process continued until the whole battery of cells is at work. The liquid is circulating under pressure the whole time, but when the moment comes that the slices in No. 1 are exhausted, all its connections are turned off, the pressure is transferred to No. 2, the bottom man-hole of No. 1 is opened, and the exhausted slices fall out. If the battery is circular, there is a pit in the centre, towards which the opening at the bottom of each cell is directed, and which receives the wet exhausted slices. That the slices may be loosened, in order to be more easily ejected, the last charge of water to that cell is directed from the bottom upwards. The cell is at once refilled with fresh slices, and becomes the last instead of the first of the series. This is, roughly, the method of working the

diffusion battery: but the rate at which it works, how often each cell is filled and emptied, and how quickly the diffusion juice is passed from one to another, are matters which require most accurate regulation and supervision. The outstanding principle of this process is that fresh beet cuttings which most readily give up their sugar come in contact with water least able to extract sugar, owing to it already having sugar in solution, and, conversely, beet cuttings which least readily give up their sugar, owing to their being nearly exhausted, come in contact with fresh water, which has, of course, a greater power of extracting sugar. In the diffusion battery this is accomplished in about nine separate stages, the addition of a fresh cell forming a new stage, but of recent years several methods have been devised to achieve in a continuous process what is usually done in about nine stages. The rapid process of diffusion utilizes a trough about 75 ft. long and 6 ft. wide, fitted with divisions forming about twenty-five compartments. Blades are fitted to a shaft which runs the full length of its semicircular base, and are utilized to lift the cuttings over the divisions and cause them to progress over each successive division, along the full length of the trough, which is set at a slight incline. The cuttings, which have been heated by steam, meet a stream of hot water running in the opposite direction, and in this way the freshest cuttings meet the water least able to absorb sugar, and, conversely, the exhausted cuttings meet fresh water most able to extract the little remaining sugar. The earliest experiments with this method of diffusion suffered from various technical defects, but improvements such as those patented by Paschen have been effected, and this method is being used on the Continent and by some of the new English beet sugar factories.

The diffusion juice is, of course, much purer than

the cane juice, which, as we have seen, is contaminated by the violent crushing to which the cane is subjected in powerful modern cane mills. The diffusion juice contains the sugar and some portion of the salts of the beetroot. It may also contain small traces of the gummy and albuminous impurities, but the bulk of them remain in the cells of the exhausted slices. Of course, in the process of cutting the slices a certain number of cells are broken, and from these broken cells the impurities must find their way into the diffusion juice.

The superiority of this process over the crushing of the cane, as described in the last chapter, is so striking, that it may well be asked why cane mills have not been superseded by diffusion. Many cane sugar manufacturers have asked themselves the same question, and some have answered it by putting up a diffusion plant. But it cannot be said that the experiment has been satisfactory. The cutting of the cane into slices is not a very easy operation, but that objection might perhaps be waived if other things went well. Diffusion involves dilution of the juice to the extent of at least 20 per cent. Maceration between the mills of a triple cane mill ought never to create a dilution of more than 10 to 15 per cent. This extra dilution in the diffusion process is a serious thing with a cane-sugar factory, which relies on its megass for the whole of its steam-raising fuel. Moreover, the megass left from the diffusion battery of a cane sugar factory is very inferior to ordinary megass as fuel, and requires pressing and drying before it can be used. This is a very serious objection. Again, a beetroot factory need rarely stop for want of roots; but a cane factory may often have to suspend work for want of canes. With mills this is easily done, but with diffusion it involves considerable loss. Suddenly to stop a diffusion battery

for want of raw material means that all the juice in the battery, most of it very thin, must be worked up as it is or a considerable loss of sugar incurred. A diffusion battery requires great regularity in the quality of the raw material; but a cane mill is obliged sometimes to work up a large extra quantity of damaged cane in a hurry. With mills this can be done, but it would be impossible with diffusion.

Diffusion can, under favourable circumstances, extract 95 per cent. of the sugar in the cane. Mills are now so much improved that, with all recent appliances, they can get more than 90 per cent. of the sugar in the cane. The reason for adopting diffusion is, therefore, not so strong as it was some years ago, and is more than counterbalanced by the disadvantages.

The exhausted beet slices from the diffusion battery are, of course, saturated with water which has to be pressed out. They are then either delivered to the farmer for cattle food or stored in pits till wanted. In the latter case they ferment, and are said to be preferred by the cattle in that state. Various methods of artificially drying the pulp have been adopted and will, no doubt, become general. The pulp makes a very good cattle food if judiciously mixed with chopped straw or hay. It can also be mixed with the molasses of the factory, which seems a very natural and reasonable plan, and a good way of utilizing a by-product which fetches a very poor price in the market when sold for distilling or to the special factories which extract its sugar by chemical processes.

The following analysis of the beetroot is given in Horsin-Déon's book, *Le Sucre et l'industrie Sucrière*. Water 80 per cent., sugar 15, cellulose and woody fibre 1, gummy matters 0.6, albumen and other nitrogenous substances 1.6, other organic substances 1,

mineral matters 0·8 per cent. Since then the average percentage of sugar has risen in many countries 2 per cent. Even the sugar actually extracted has risen in some favoured districts to more than 16 per cent. in a good season, which easily exceeds that obtained from cane. But the beetroot farmers only produce on the average, in the most favoured countries, 10 to 14 tons of roots to the acre, whereas the sugar cane is produced at the rate of 20 to 40 tons to the acre. The sugar cane in Java, that most successful sugar-producing country, cannot be said to contain, on the average, more than 12 to 15 per cent. of sugar, and the quantity actually extracted does not, on the average, exceed $10\frac{1}{2}$ to $10\frac{3}{4}$ per cent. But, as has been already stated, they produce in Java, on the average, more than 5 tons of high-class sugar to the acre. The average production of European beetroot sugar is well under 2 tons to the acre, and in England it is $1\frac{1}{2}$ tons of white sugar.

There is one peculiarity of the beetroot juice which is of great importance: it contains no uncrystallizable sugar. Good raw beetroot sugar, therefore, is entirely free from what is roughly called glucose. The juice, moreover, is not acid and, therefore, does not become inverted so rapidly as cane juice. Here beet has a great advantage over cane. But in some of our sugar colonies, Jamaica and Demerara for instance, the final product, molasses, which of course contains, among other things, the invert sugar existing in the cane and largely increased in the process of manufacture, is converted into rum, which is a valuable by-product of the industry in those countries.

As to the extra purity of diffusion juice in a cane sugar factory, as compared with mill juice in the same factory, Noël Deerr, in his excellent book (1905), *Sugar*

and the Sugar Cane,¹ gives the figures from a Cuban factory working mills and diffusion side by side. Sometimes the ingredients of a sugar solution are defined roughly under only two designations—"sugar" and "non-sugar." The object of a sugar factory is to get out as much sugar and as little non-sugar as possible.

	<i>Mills</i>			<i>Diffusion</i>
	Breaker	1st Mill	2nd Mill	
Non-sugar } per cent. }	2.01	2.25	2.54	1.32
Purity quotient	89.7,	87.8	86.5	90.3

The difference is not so striking as might be expected.

¹ Published by Norman Rodger, 2 St. Dunstan's Hill, E.C.

CHAPTER V

CLARIFICATION AND FILTRATION

THE speed with which canes should be brought to the mill to be crushed, so as to avoid the danger of rapid changes in composition, is still more important with the juice itself after its extraction from the cane. It contains many kinds of impurities, and the more complete the extraction the greater is the amount of impurity. Among other things there are the organisms of fermentation which would at once commence if the juice were not speedily subjected to the operations of clarification and defecation.

To go back again to primitive methods, such as still exist in primitive countries like British India, China, the Philippines, and even some parts of Brazil, the juice is at once poured by the small native grower into an iron pot over a wood fire ; wood ashes and lime are added, which create scum. This is skimmed off the top until it ceases to rise, and the clear juice is then allowed to boil until it reaches the point where it will crystallize when cooled. When cold the crystalline mass is removed, and is ready for the market. In India it is called Gur or Jaggery ; in the Philippines, Taal or Zebu, or Ilo Ilo, according to the district from which it comes. In Brazil it has many strange names, but here it was called by the name of the port of shipment, Pernams (Pernambuco), Bahias, Maceios, and so on. Those from India, Manilla, and China are dark brown masses of sugar and impurities mixed up together. These sugars, and those from Brazil, used to come to this country in considerable quantities from time to time when prices were high, and formed no small part of the raw material of some British refineries.

In our West Indian Colonies the process of clarification was carried on in a similar but much superior fashion. The "Copper Wall" was universal seventy years ago in the West Indies. It was simply a row of copper basins, with a blazing fire underneath them going the whole length of the row and then up the chimney. The juice, much purer than that from the powerful modern mills with all their appliances, contained, nevertheless, much albuminous and gummy matter which had to be removed. The copper wall combined clarification and crystallization. In the first copper milk of lime was added, and the scum skimmed off; in the succeeding coppers, to which the juice was ladled from No. 1, a further skimming or brushing took place, and when the juice reached the last of the six coppers it had become thick enough and pure enough to crystallize when cool into an excellent raw sugar, called muscovado, the principal raw material of the British sugar refiner seventy years ago.

But new appliances, in the course of time, took the place of the copper wall. The vacuum pan was invented for carrying out a more perfect kind of crystallization. Then came the European beetroot industry, which introduced many varieties of clarification and defecation. Capable men took up the subject and gradually developed a really scientific system of dealing with sugar juice. Lime was still the basis of the system, but it was no longer used in a haphazard or rule-of-thumb manner. Lime is absolutely necessary, especially with cane juice, which is naturally acid, but though it removes impurities it is liable to create more than it removes by forming lime compounds very detrimental to the subsequent crystallization. The beetroot factories proceeded to get over this difficulty by introducing carbonic acid gas into the defecating pans, which

precipitated the excess of lime in the form of insoluble carbonate. The cane sugar manufacturers are learning the lesson from their European competitors, and are now beginning to practise, in countries where science reigns supreme, as complete a system of defecation by lime and carbonic acid as can be found in the most up-to-date beetroot factory.

We must skip over as lightly as possible the intermediate processes which preceded the perfected methods of to-day. The copper wall was superseded by an operation completed in one vessel, where the juice was heated by steam, the lime scums removed from the surface and partly allowed to fall to the bottom of the vessel, from which they were subsequently removed, the clear juice being run off for concentration in the vacuum pan. Another method was to heat the juice in a special juice heater and then, when the air bubbles had thus been removed, run it into the defecating pan where lime was added, the lime and impurities all falling to the bottom in the absence of air bubbles, and the clear juice being decanted.

In all these various processes the important point was to hit off the exact quantity of lime necessary. Too much lime would be worse than too little. But even when exactly the right quantity was used it did not remove all the impurities. Many modifications were introduced, continuous defecators were invented, new methods of heating the juice before entering the defecator were adopted, but no really satisfactory results are likely to be obtained until the lessons taught in the beetroot factories are learned and applied. The preliminary heating of the juice before defecation not only drives out the air bubbles but, what is much more important, coagulates the albumen. The addition of lime in the defecating pan not only neutralizes the

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acidity of the juice but also combines with the albumen and creates flocculent precipitates which carry down with them a portion of the gummy impurities and also all suspended substances, such as fibre, wax, colouring matter, and the dirt which had adhered to the canes. The albumen is almost completely removed. The gums and pectine, a gelatinous substance akin to gum, are reduced to about half their quantity, and the quotient of purity is raised about two per cent.

But great skill and care are necessary in this process of clarification. Too little lime fails to carry away all the acids, albumen, and gummy matters, and the precipitation is imperfect and slow. Too much lime, on the other hand, attacks the glucose, combines with the resulting organic acids, and forms viscous substances very injurious not only to the subsequent crystallization but even to the body of the sugar itself. The exact point of right quantity can be ascertained by rough experiment easily carried out, but it all depends upon the operator that this shall be done correctly. In making raw sugar for the refiner the object of the operator is to keep the juice as nearly neutral as possible, but with a slight tendency towards alkalinity. This secures that the resulting sugar, when crystallized, shall not be acid and, therefore, shall not deteriorate in quality.

But there is much sugar made now, called "Demerara sugar," which is intended to be consumed in the form of raw sugar. Large quantities of sugar were, in former days, consumed in the raw state. They were the superior kinds of muscovado sugar, from Barbados, Jamaica, and Porto Rico. It was only the lighter coloured varieties with a yellowish tinge which were good enough for the grocer. They were sweet and fragrant, with a pleasant flavour of the sugar cane.

But when the home refiners produced yellow sugar with a pale primrose tint the old muscovadoes were thrown rather into the shade. Then came the new raw sugars from our colony of Demerara which soon cut out all competitors. They were crystallized in the vacuum pan and had a large bold crystal of a pretty yellowish tinge. Trinidad followed the example of its neighbour, then came St. Lucia, and now many more imitators.

There is no secret now as to the method of preparing the juice for making this sugar. A few words are sufficient to give the 'general reader an idea of the special preparation of the juice when "yellow crystals" are to be made. There is a gas called sulphurous acid, the product of burning sulphur, which has the property of bleaching vegetable substances. In the days when sulphur matches existed boys used to light one and hold a flower over the smoke to see it turn white. The cold juice from the mill, heavily limed, is pumped to the top of a tower or vertical box, where it runs down the inside over a series of perforated trays which scatter the juice in a shower. Sulphurous acid gas is introduced at the bottom under pressure, so that the juice and the gas thoroughly mingle. While the juice is descending the gas is rising to the top of the tower. An alternative system is to blow the gas through perforated pipes into the bottom of a tank full of cold limed juice. The effect of these processes is to nearly neutralize the lime with sulphurous acid. The viscosity is greatly reduced and the subsequent work of crystallization and "curing" greatly facilitated. The juice must not be heated until neutralization is nearly complete. The action of the acid on the cold limed juice is to bleach it, and to break up the soluble organic salts, substituting insoluble sulphites. The resulting juice, being now

acid, is bright in colour, but in order to maintain this colour up to the time of crystallization it is necessary to keep it rather on the acid side of neutrality. If there is any fear of alkalinity, phosphoric acid is used in the defecator, which precipitates any excess of lime. Of course, great skill and experience are necessary in carrying out this special process for the purpose of producing bright yellow crystallized sugar, first by maintaining the bright colour of the juice and, secondly, by avoiding the danger of "inversion" in its slightly acid state. When all precautions are properly taken the result is a bright yellow sugar which fetches a high price; but if not, the product will be a dingy yellow or even grey sugar, and will not be a success in the market. When there is a poor demand for yellow sugar the factory goes back to the ordinary defecation process and makes "refining centrifugals" for sale to refiners. The cost of production is less, and the yield of sugar is generally rather better—and there is always a market. In some factories it appears that the treatment of the cold juice with the acid precedes the liming of the juice, apparently a still more dangerous process. It is said that yellow crystals are more difficult to produce now that more powerful mills produce a juice of less purity.

We now turn to the clarification and defecation of the beetroot juice, and must enter on a brief review of the processes which led up to the present perfected system of what is called "carbonatation." The juice of beetroot, like that of cane, contains certain impurities which have to be removed before the juice is fit for filtration, evaporation and, finally, crystallization. Fortunately it contains no glucose and, therefore, there is no creation of those inconvenient and injurious organic acids which are produced in cane juice when

Queensland Government

VACUUM PANS

By permission of the

the lime attacks and decomposes some of the glucose. In the beginning the beetroot factories followed the example of their brethren in caneland; they added lime, the scum at the top was removed, the heavier impurities sank to the bottom, and the intervening clear juice was drawn off. That was simple clarification. The juice was then boiled in open pans, and allowed to crystallize as it cooled; the result was a very excellent raw sugar. It is a curious fact that sulphurous acid, was tried with beetroot sugar more than a hundred years ago; but science was not sufficiently advanced in those days to make it a safe experiment. They even tried sulphuric acid as a means of throwing down the excess of lime, and with some success. This method was practised more or less up to 1849, when the idea of using carbonic acid gas made its practical appearance. It was called the *Rousseau* process. The juice, after decantation from the defecating pan, was saturated with the gas until the whole of the excess of lime was thrown down in the form of insoluble carbonate. Ten years later Périer and Possoz introduced double carbonation, which is now the universal system. The name of Jelinek is attached to this system in Austria. New industrial methods and new scientific ideas have a habit of springing up simultaneously in various quarters.

Among the gummy impurities is included pectine, which, if the raw juice were left to itself, would rapidly decompose into gelatinous substances converting the whole mass into a sort of jelly. Other fermentations would follow and attack the sugar itself. Lime throws down this pectine as well as the organic acids, and coagulates the albumen in a hot juice. But in a hot juice the lime, if not neutralized, would form with the sugar various sucates (or saccharates) of lime, some soluble but some, unfortunately, insoluble. Here

would be a great loss of sugar because the insoluble sucrate would disappear in the scum. Hence the absolute necessity for some acid to neutralize the lime and to set free again the sugar from its unstable combination. There is another combination of sugar with lime, discovered or defined by Boivin and Loiseau in 1868, which is interesting for other reasons. They called it the sucrate of the hydrocarbonate of lime. It is a gelatinous body but is broken up by further addition of the gas.

It is clear from these facts that it is necessary to saturate the limed juice thoroughly with carbonic acid in order to make sure that no sugar finds its way into the scum, and to commence the saturation before applying heat. But if the saturation were carried too far part of the precipitated carbonate, which had carried with it not only the impurities but also the colouring matter, would become soluble, and the decolorized juice would again become coloured. In the double carbonation the saturation is stopped before this danger-point is reached, the decolorized and purified juice is drawn off, and a second operation commenced. More lime is added, and the juice is again saturated with the gas up to the point where it is nearly, but not quite, neutral.

The details of the operation may now be briefly described. Milk of lime is added to the cold juice directly it comes from the beetroot. This operation is preferably performed in a separate vessel with a mechanical stirrer. The limed juice then goes to the carbonating vessel and the gas is injected while the juice is still cold. Great frothing takes place, which is kept down as much as possible by various means, and a cover to the vessel is necessary to keep back any overflow, and to allow superfluous gas to be carried

off up a chimney. When the action is in full force moderate heat is applied through a steam coil at the bottom of the vessel. The frothing begins to slacken and tests are applied to samples of the juice to detect the right point of alkalinity, nearly approaching to neutrality. At that point it is found that a sample of the juice in a glass indicates a quick and steady precipitation of carbonate of lime, leaving a clear bright juice above. It is now ready to go to the second carbonatation. Decantation of the clear juice has, of late years, been given up, as it is found difficult to prevent some admixture of sediment. The apparatus called a filter press was invented, through which the juice and the precipitate are forced by pressure. The clear juice flows out, and the lime precipitates are retained in the chambers of the press in the form of flat cakes containing the lime and the impurities of the juice. A large number of these filter presses form an important part of the plant of a beetroot sugar factory. The clear, bright juice goes to the second carbonating vessel, more lime is added, the gas is passed through the liquid until the lime is completely saturated, the heat being raised higher than in the former vessel, and the operation is finished. The juice again goes through other filter presses, and is ready for evaporation and then crystallization.

This was the process when the juice was extracted in the old way by hydraulic presses. But now that diffusion has become universal and furnishes a much purer juice, there is no necessity to operate in the first instance on cold juice. The juice from the diffusion batteries is already hot, and it is found that if this heat be kept up, and even increased, the defecation goes quicker, and with the purer juice, also goes safely. Less lime may also be used, but not to the extent of making

the first carbonatation imperfect, which would impede the filtration.

In Java, where a large quantity of white sugar is now turned out fit for direct consumption, the carbonatation process has been adopted in many factories, and at one time it seemed probable that its use would go on increasing. In cane juice there is a small quantity of glucose. In the ordinary defecation, at a high temperature, the lime attacks the glucose and forms dark coloured, viscous substances which are most inconvenient. But when working at the lower temperature of the carbonatation process these lime salts are partially insoluble, the rest being colourless and innocuous. The juice becomes clear, light in colour, and easily filtered and evaporated. Much more of the gummy matters are thrown down than in the ordinary defecation process. A second carbonatation is just as necessary with cane as with beetroot juice, and for the same reason. The first filtration must take place while the juice is still alkaline, otherwise part of the precipitate would be redissolved, and the juice would become coloured. Considerable quantities of lime are necessary in order that the viscous precipitates may be mingled with sufficient lime to make the filtration go well. It is rather difficult to secure absolute neutrality in the final juice and, therefore, a further saturation with sulphurous acid is sometimes found advisable, which also improves the colour of the juice.

This carbonatation process is obviously a more expensive operation than ordinary defecation, but if white sugar is to be made direct from the cane juice it is considered essential. As to white sugar in Java, a change has taken place in the method of manufacture which may, in the future, have important and wide-reaching results. The carbonatation process, as has

been explained, is an expensive process requiring great skill and care. It requires a large mass of special machinery, including lime-kilns for the production of lime and carbonic acid; and those kilns require fuel. In tropical countries, limestone and fuel may be difficult to obtain. But a still stronger objection to the carbonatation process in Java is that frequently a factory may find it necessary, for market purposes, to go back to the production of raw sugar when the demand for that sugar is stronger than the demand for white sugar for India. The carbonatation process would make it too good. The planters, therefore, tried experiments, and found that neutralizing the lime with sulphurous acid, a simple process, would, if properly carried out, clarify the juice so well that white sugar quite as good in every way could be turned out. More than half of the Java crop is now white sugar of excellent colour and quality. In the case of the beetroot, it has enabled well-managed factories to produce excellent refined sugar.

The original intention of the Continental factories was to produce 88 per cent. raw beet sugar, 75 per cent. raw beet sugar and molasses which was sold for cattle feeding or for distilling purposes. Processes are, however, now in use, both on the Continent and in England, for extracting the sugar from molasses by forming chemical compounds with calcium, barium, or strontium. These compounds are easily separated from the impurities and water in molasses, and are then split up, by the addition of carbon dioxide gas, into sugar and carbonate. Owing to the accuracy of present-day chemical control the tendency is for factories to manufacture white granulated sugar instead of 88 per cent. and 75 per cent. raw beet sugar, and this is being done in the new factories in this country. Even as far back



JAVA—DIGGING OUT A CANAL TO PROVIDE A PLANTATION WITH WATER

as 1871 loaf sugar was produced direct from the beetroot juice, and, at a later date, Langen, the inventor of the process for making cube sugar, produced fine cubes in his own beetroot sugar factory.

These are some of the wonderful results of science applied to sugar production, which point to a great development in the future.

CHAPTER VI

CRYSTALLIZATION

HAVING clarified and purified the cane juice, the next step is to evaporate the water with all speed until crystallization takes place. This, as we saw, was done in the last coppers of the copper wall. But the great waste of fuel and the excessive heat spoilt the sugar and soon led to a search for better methods. They cannot all be enumerated, much less described, in a popular treatise, but a few are worth a passing notice. Alfred Fryer, the Manchester sugar refiner, maintained that the proper way of making sugar in the tropics was to do so as quickly as possible, and at a minimum cost, and to send the rough raw material home to be converted into refined sugar. He, therefore, invented, constructed and worked, about sixty years ago, in the West Indies, a simple apparatus called Fryer's Concretor. The clarified juice is run, in a thin stream, over a long sloping platform of metal divided by trays into a series of lanes from side to side, along which the thin stream of juice slowly meanders in a zigzag direction. Heat is applied underneath, and the thin film of juice evaporates so rapidly that by the time it arrives at the other end of the platform it is nearly ready to crystallize. The evaporation is finished in a cylindrical vessel fitted with plates which slowly revolves, hot air being at the same time injected. This finishing process exposes the juice to further heat, and completes the evaporation. The juice is then run out, and allowed to crystallize at its leisure into solid blocks, which Fryer very appropriately called concrete. This ought

to be a very cheaply produced article of commerce, and the idea appeared to be sound. But unfortunately the concrete never "caught on" in the market.

Another method of rapid evaporation of juice in the form of a thin film was introduced about the same time, called the Wetzell pan, the principle of which was to heat the juice in a long trough in which slowly revolved a long cylindrical wheel armed with a series of discs, which constantly exposed, in its slow revolution, a thin film of juice to the air, and thus set up a rapid evaporation. Another form was to heat with steam the wheel instead of the vessel containing the juice, or to make the wheel to consist of a series of steam pipes, placed either lengthways or round the circumference. This method involved the expense of an engine to drive it. At that time some of his brother sugar refiners were one day explaining to Fryer the new method of the Scottish refiners in boiling their yellow sugars at a very low temperature, which not only improved the colour but also enabled them to sell more water in combination with the sugar. "Ah!" said Fryer, "that must be the wet sell process."

The Aspinall pan was another early system of evaporation by steam heat. The steam passed into a chamber in the pan, through which the juice circulated along a series of vertical brass tubes until it was ready to crystallize, when it was drawn off. Many modifications of this were introduced, but all had the serious defect of over-heating the juice. Also, when the juice thickens evaporation goes on with great difficulty because actual ebullition at the temperature necessary for that operation would be fatal. Hence the introduction by Howard of the vacuum pan, where the thick juice can be boiled violently at a perfectly safe temperature. A solution of sugar must be heated above 212° F., the

boiling point of water, before it boils; but in a partial vacuum it boils violently at 160° F., and at even a lower temperature in a more perfect vacuum. It is a cylindrical vessel with domed top and bottom, made of copper, provided inside at the lower part with steam coils, and also with a steam jacket. An air pump creates a partial vacuum, and a condenser, through which the steam from the boiling juice passes on its way to the air pump, by rapidly condensing the vapour, greatly helps to increase the vacuum. The juice is always boiling more or less violently, even when thick, and, therefore, throwing off its vapour freely. This pan, in its complete form, appeared about the year 1830, and about thirty years afterwards began to be used in the tropics as a useful adjunct to the preliminary evaporation of the thin juice. The vacuum pan, in fact, finished the operation. But it did more than this, it enabled the factory to produce a more distinctly crystalline form of sugar than the old muscovado kind, which comes from the confused crystalline mass formed by the spontaneous crystallization of the thickened juice when, on cooling, it crystallizes of its own accord. But the use of the vacuum pan did not become extensive for many years. Mauritius and the French West Indian Islands were the first to use it on any considerable scale; then came Demerara, Berbice, and Trinidad. Now it is used everywhere, except in primitive countries.

The vacuum pan puts the finishing touches to the thickened juice, but a great deal of evaporating has to be done before the juice arrives at that state. Another kind of vacuum apparatus has been invented as best suited to that earlier stage. The French call it the *Triple-effet*, and that is now its name. It is a very ingenious and successful contrivance, and came from

France, at that time the leading country in the production of beetroot sugar. The inventor, Rillieux, had to pass many long years, as inventors generally do, before he could procure a good trial of his new idea. In the old days of open pans and the heat of a naked fire the French manufacturers had to burn 8 cwt. of coal for every ton of roots worked. When steam was substituted for fire heat, and the steam engine was allowed to enter the factory to drive an air pump for the vacuum pan, they managed to do the work with 5 instead of 8 cwt. of coal to the ton of roots. Rillieux proposed to make a further great reduction in the cost of fuel by evaporating the greater portion of the water in the thin juice in a double or triple arrangement of pans, where the steam from the boiling juice in the first should heat the second, and so on. This began to be accomplished about the year 1852. By 1882 it was brought to a fair degree of perfection, and the amount of fuel per ton of roots was reduced to $1\frac{1}{2}$ cwts.

The apparatus may be roughly described as consisting of three vertical cylindrical vessels with dome-shaped heads, ending in a wide neck which turns over and downwards carrying the vapour to its next destination. The lower part of each vessel is divided into three parts, a small space at the bottom, then a much larger space enclosed by two horizontal iron plates forming the "steam drum," fitted with vertical copper pipes permitting the juice, which enters at the small space below it, to pass through the steam drum into the large open space above it. The juice is allowed to rise above the top of the steam drum, but not far enough to incur the danger of boiling over. The final vessel of this triple-effet is connected with the air pump and condenser. Low pressure steam enters the drum

of the first vessel, the thin juice boils and begins to thicken. It is transferred to vessel No. 2; vessel No. 1 being charged with fresh juice. The steam from the evaporation of the juice in No. 1 goes into the steam drum of No. 2, and boils the partially thickened juice. There is a slight vacuum in No. 2; and even in No. 1 a slight vacuum is created by the rapid condensation of its steam in the drum of No. 2. In No. 3, the vessel nearest to the pump and condenser, the vacuum is greater. The still thicker juice in No. 2 goes into No. 3; No. 2 is filled from No. 1, and fresh thin juice goes into No. 1. The triple-effet is now in full work, which goes on continuously. The steam from the boiling juice in No. 2 goes into the steam drum of No. 3, and not only boils the juice there, but improves the vacuum in No. 2 by its rapid condensation. The transfer of juice from vessel to vessel, and from the thin juice tank to the first vessel, takes place every time that a charge of sufficiently thick juice is drawn from No. 3 to be cleaned and to go to the vacuum pan. The arrangements for drawing off the water of condensation, and the precautions against loss of sugar by the carrying over of bubbles of juice in the steam, need not be detailed, nor the cleaning of the copper tubes, and many other necessary operations connected with this complex apparatus.

Here we have not only a great saving of steam, but also a complete method for avoiding, as much as possible, any injury to the sugar when the juice becomes thick and, therefore, more sensitive. But the juice, which was perfectly clear and bright when it entered the triple-effet, loses its brightness as it passes through the process of thickening, because many substances which were soluble in the thin juice become insoluble as it thickens. These substances make the juice turbid, and also deposit themselves in the tubes, which, therefore, require

constant cleansing. In the case of cane juice, phosphate, sulphate, carbonate, silicate and oxalate of lime, oxide of iron, silica and a few organic impurities are found in this deposit. For this turbid, thickened juice, a further clarification is necessary. If it has been through the double carbonatation there will be no difficulty in the filtration, but in the case of cane juice from the ordinary defecation it must be treated again in the defecating pans, and neutralized, if necessary, with sulphurous or phosphoric acid, or, if acid, with soda. These help the settlement of the precipitate. Acidity in thickened cane juice may come from fermentation. The only way to avoid this fatal trouble is cleanliness. That must be the first rule in every sugar factory or refinery. The triple-effet is now used universally in all large sugar factories, and has sometimes become a Quadruple-effet. Many modifications have appeared but need not be described here in detail, though they are interesting and instructive. Some are film evaporators, and some substitute horizontal for vertical pans.

The thick juice, after filtration, goes to the vacuum pan, and its treatment there depends on the kind of sugar to be made. It may be boiled into large grained yellow crystals, as in Demerara; or into still larger grained sugar which is afterwards washed white, as in France; or into small grained sugar, afterwards washed white, as is the practice in Germany, Austria, and Russia, in making "granulated"; or into a superior crystalline raw sugar for the use of sugar refiners, as is the case in Cuba, Peru, St. Domingo, Java, and many other progressive cane sugar countries, and also in most of the beetroot sugar districts of Europe; but seldom in the United States, where "granulated" is almost universal. This kind of refining sugar is called "centrifugal" to distinguish it from the lower classes called

muscovado. The "mother liquor" from the first crystallization is either boiled into a second product or taken back into the pan to mix again with the boiled mass.

The vacuum pan, which used to be quite a small, nearly spherical vessel, is now made of an enormous size for the use of factories where large quantities of juice have to be dealt with. These large pans, instead of having only one steam coil, are armed with a series of them, the steam being first turned on in the lowest, and then into each in succession as the pan gets fuller. The process of boiling and crystallizing sugar in the vacuum pan is quite a fine art. It must suffice to describe it very roughly in this popular treatise. Moreover, there are infinite varieties of treatment, dependent upon the purity or impurity of the material operated upon, and the kind of sugar the operator desires to produce. For instance, the loaf sugar which we see in a Paris restaurant, a dull white lump of sugar without any sparkling grain, is not completely crystallized in the pan. The liquor is boiled down to such a thickness that it will further crystallize while cooling. It is run into the loaf-moulds where it rapidly crystallizes as it cools and forms a dull granulated mass. On the other hand, the sparkling loaf or cube sugar used in this country is made by most careful and skilful crystallization in the pan. The liquor, as it covers only the lowest of the steam coils, is brought to the crystallizing point, and then much skill is needed. Not only can the boiling liquor be looked at through a window in the pan, but samples can be taken from the hermetically sealed pan, with what is called a proof-stick. The pan-man carefully watches the appearance of the minute crystals and allows just enough liquor to flow in to prevent a confused mass of crystals being suddenly formed. He

thus maintains what is called an even grain—grains all of one size. It is his business to maintain the even grain from that moment until the pan is full, and the boiled mass in an exactly fit state to go out, either to the centrifugal machines or to the sugar moulds. He allows the grains to come closer and closer together as time goes on, and if he has done his work well it will be found, when the contents of the pan goes down into the receiver below, that the boiled mass—the *massecuite*, as the French call it—contains a very even-sized grain, with as few small grains in between as possible. This is most important in making crystallized sugar which is to be washed white in the centrifugal machines, because there would be a wasting of the fine white “first product” if any of the smaller grains found their way out with the adhering syrup, and were thus degraded into the after products. These rules apply equally well in the case of white or yellow crystallized sugar made in cane or beetroot sugar factories. The French white crystals are boiled very large, and with excellent skill. German, Austrian and Russian “granulated” are boiled to a much smaller grain. The pan is filled much fuller before grain is allowed to appear; then the boiling is allowed to go much quicker than in the former case, and the result is a uniform very small grain.

The centrifugal machine requires no great explanation. Drums with perforated walls spin round at great speed. The boiled mass, carefully mixed and stirred in a vessel above the centrifugals, is run into them; the syrup flies off through the perforated wall of the drum, and is caught and carried away from the outside of the drum, as a second syrup, to be boiled again into a second product, or perhaps to be taken back into the next boiling of the same pan to form part of what, by

courtesy, is still called "first products." This is a very important modification in these latter days, which must presently be explained.

The stage of finished crystallized sugar is thus rapidly attained. If it is "centrifugal," that is, a kind of superior raw sugar for the use of refiners, it simply goes into bags when cold, is weighed off, and ready for shipment. White crystals, and "granulated"—white crystals with a very small grain—are carefully dried before bagging. Granulated is dried in a heated revolving cylinder. The process is simple and rapid, and the sugar is soon ready for the bag.

The only matters requiring notice are the after-products. They used to be considerable, but their quantity is gradually becoming smaller, and, therefore, less important. In Java, where the practice is to take syrups back into the pan, thus swelling the quantity of so-called first products, the low black final product is very small in amount. In some countries the second products are so good in grain and colour that they fetch a satisfactory price in the market. The beetroot factories often turn out an excellent second product, much sought after by the refiner.

A new method of dealing with the after products of the factory is now much employed. In boiling a viscous, impure, second syrup, it is not possible to produce in the pan as much grain as the syrup is capable of forming. But if the *masse-cuite*, after it leaves the pan, be subjected to a quiet stirring motion the portion of the syrup which was unable, owing to the inert state of the mass, to crystallize in the pan, will begin to deposit a further amount of sugar in the crystalline form, not by making new crystals but by building up the crystals already existing in the mass. This has been called "crystallization in motion." The same process may

be applied to the so-called first-product, which has been boiled not only from pure juice but also, at the end of the boiling, with an admixture of second syrup. This addition makes the *masse-cuite*, at the end of the operation, more viscous than it otherwise would be ; but the process of subsequent stirring helps the viscous syrup to deposit more sugar on the grains, and the result is a good imitation of a genuine first product.

The scientific explanation of this method of adding a less pure syrup to the pan nearly full of a first product *masse-cuite* is worth a moment's attention. As long as the boiling, and, therefore, evaporation, of the crystallized mass in the pan continues, the "mother liquor" in which it moves should continue to deposit fresh sugar on the crystals. But the time comes when the mass is so dense that it is impossible to continue the crystallization. That is the time to introduce some second syrup, that is, the "mother liquor" from the previous *masse-cuite*, which has been thrown off in the centrifugal machine. This at once makes the dense mass of sugar in the pan more fluid, and enables the deposition of sugar on the crystals to begin again. This further crystallization comes not only from "the mother liquor" in the pan but also from that brought in from the centrifugal machines. The subsequent stirring in the apparatus for promoting crystallization-in-motion adds still more sugar to the grains of crystal, and thus the second syrup is induced to yield a considerable quantity of its sugar in the form of good first product. It looks as if this could only be carried on up to a certain point ; but that difficulty can be got over by doing it in two stages. A small quantity of juice is boiled to *masse-cuite* and mixed in the pan with as much of the now nearly exhausted second syrup as will reduce the purity of the "mother liquor" to the desired point.

The mass is boiled to a high concentration, let out into the coolers and cooled in motion down to a fixed temperature for a considerable period—several days. The subsequent curing of this in the centrifugal gives a sugar equal to first product “in quality and appearance,” and a syrup which is practically exhausted molasses. Dr. Prinsen Geerligs, the eminent Java expert, gives very full details of this most important new departure in the science of sugar production. He declares that, if well conducted, this system will get rid every day of the same quantity of exhausted molasses as enters the factory in the juice in the form of impurities and non-saccharine matter. Those who are sanguine of the result of this new process look forward to the time when there will be only two products of the factory—first products and molasses.

This brings us to molasses, and to some interesting points with regard to it. In places like Jamaica and Demerara, celebrated for their rum, there is no question what to do with the molasses, it goes to the distillery and is made into rum. The sale of rum in these countries is an important item in the account. The receipts from that product can be credited in the final account so as to show a very much lower cost of sugar production. But where rum is not made it becomes a great problem, in cane sugar countries, what to do with the molasses. In some beetroot countries it goes to the ordinary distiller. In Germany it goes to special factories which extract the sugar from it by chemical processes, and actually produce white sugar as their final product. These factories produce in this way about 100,000 tons of sugar a year, which is credited to Germany as part of her yield of sugar from the roots. In beetroot sugar there is no glucose, but in the molasses there is a small quantity, the product of injury to the syrup

during the manufacture. The reason why there is molasses is the presence of salts. The theory is that these salts prevent a certain quantity of sugar from crystallizing, and that is the sugar which is held in suspension by the salts in the final syrup, called exhausted molasses. It was much discussed, some fifty years ago, what this melassigenic power, as the French called it, amounted to. The theoretical figure was that one per cent. of ash prevented 3.5 per cent. of sugar from crystallizing. But practically the figure 5 has been adopted as the coefficient. A raw beetroot sugar which contains, by the polariscope, 94 per cent. of sugar, and 1.2 per cent. of ash, as determined by incinerating a weighed portion of the sugar, moistened with sulphuric acid, in a platinum dish, is estimated to yield 94— $(1.2 \times 5) = 88$ per cent. of pure sugar. Beetroot sugar is now bought and sold on this basis of 88 per cent. net analysis, as ascertained by this system, the invoice price being raised or lowered, per degree or fraction of degree, according to the actual analysis of the sugar delivered. On the other hand, cane sugar is bought and sold, basis 96 polarization; that is the actual quantity of sugar, as determined by the polariscope, contained in the raw "centrifugal" sugar. And, in the same way, muscovado sugar is sold, basis 89 polarization; the degrees, up and down, being charged or allowed for in the invoice of the actual sugar delivered.

Cane juice contains a certain quantity of glucose, and this is increased during the manufacture. At one time it was thought that the presence of this glucose, as it may be called roughly, prevented a certain quantity of sugar from crystallizing. This has been stated, by Dr. Prinsen Geerligs, to be erroneous. He also states that a subsequent theory, of the crystallization being prevented by the viscosity of the molasses, is also

unsound. His present theory is that there is a chemical combination of the sugar (sucrose) with other constituents in the molasses, forming very soluble bodies, much more soluble than the sucrose or those other constituents when existing in their separate forms. For instance, a solution of common salt dissolves more sucrose than the water contained in the solution would do. Dubrunfaut, a French sugar expert of the middle of the last century, first pointed this out, and many investigations were made at that time as to the melassigenic power of various salts. But the new theory of a chemical combination of salts with the sucrose leads to somewhat different conclusions. The solubility of the constituents is regulated by the solubility of their combinations, and not by the solubility of the bodies in their uncombined state. On the other hand, the presence of glucose does not make the sucrose more soluble. Its presence is found actually to decrease the solubility of sucrose in the presence of salts; that is to say that, where glucose and salts are present in the solution, the amount of sucrose crystallizing out increases in proportion as the liquid contains more glucose for the same amount of salts.

This is a rather long story, but it is worth putting on record as a definite explanation of the formation of exhausted molasses, hitherto more or less a mystery, but now clearly defined by Dr. Prinsen Geerligs' laborious investigations. He gives seventy-seven analyses of Java molasses with most elaborate details. Finally, he defines an "ideal molasses as a compound of sucrose, salts and water in the approximate proportions of 55, 25 and 20," and "a factory molasses as a syrupy compound of sucrose, glucose and fructose, in varying proportions, in combination with organic and inorganic salts, and holding in solution or suspension gummy

and nitrogenous matter, silica, iron and calcium phosphates and other similar bodies."

The use of molasses as a cattle food is widespread. Mr. Hughes discovered that a mixture of molasses with the pith of the sugar cane produced a substance of a dry, mealy consistency, which could be transported to consuming countries in bags without losing its dry character. It was named "Molascuit"—rather a far-fetched and not very attractive word. It contained 75 per cent. of good sweet West Indian cane sugar molasses, and 25 per cent. of the dry cellular tissue of the sugar cane, a very nourishing mixture. Similar products are now made in this country and prove quite satisfactory.

In many countries it is difficult to know what to do with the molasses. It has been tried in the boiler furnaces mixed with megass, but it forms masses of coke which choke the bars, and sometimes even combines with the silica of the cane and forms a sort of glass or slag, which makes a worse stoppage. But if special furnaces are made it is found that the molasses, blown in the form of a spray, makes very good fuel. Another use for it is to spread it over the fields and plough it in.

A word or two as to the chemical control of sugar factories and refineries must not be omitted. In these days of scientific perfection, as the only alternative to "going to the wall," this is absolutely essential. In a refinery, the quantity of pure sugar entering the refinery in the form of raw sugar must be compared with the quantity of pure sugar leaving it, whether in the form of pure sugar or of yellow sugars, or shut up in the treacle or golden syrup. Then the value of the unit of pure sugar brought in can be compared with that contained in each product going out; thus the profit on each class of sugar produced can be

defined and compared to a nicety—very valuable information. The syrup at each stage of the operations should also be examined in order to ensure uniformity of work. Coal and charcoal must be watched in the same way, and so must scums, charcoal washings and such-like matters. In a cane sugar factory all this must be done, but it is much more difficult. An accurate knowledge of how much sugar enters in the form of cane is almost impossible. Even to weigh the cane accurately is an arduous task ; and even then it varies in quality so constantly from day to day that any estimate can, at the best, be only approximate. Nevertheless it is done, and very fair figures are given, in good factories, of sugar coming in, going out, and lost. Cane, megass, juice, masse-cuite, syrups, molasses, waste waters and finished sugars are all weighed or measured, and analysed. The beetroot factories were the first to show the necessity for all these things, and the best way to do them. Cane sugar makers have learned the lesson, and so have the refiners.

CHAPTER VII

SUGAR REFINING

WE have seen how sugar production, whether cane or beet, grew from small beginnings and primitive processes into the great and highly scientific industry of to-day. Sugar refining has also grown in the same way, but it has also been so much modified from time to time, and so much adapted to the varying requirements of different classes of consumers, that its progress has not been so definitely in the same direction as is the case with cane or beet sugar production.

Seventy years ago sugar refining here was much the same as sugar refining in other countries. But very soon the English and Scottish refiners began to use a much lower quality raw material than their continental neighbours, and this involved different methods and different results. The essential characteristic of sugar refining, as distinguished from the processes involved in producing sugar from the juice of the cane or the beetroot, is the use, in small or large quantities, of animal charcoal made from bones, or of decolorizing carbon made from vegetable matter, for decolorizing sugar solutions. The foreign refiners deal with a very high class of raw material, and, therefore, require only a very small quantity of charcoal or carbon for filtering their sugar solutions. In France, for instance, the greater part of the raw material is nearly white beet sugar and, consequently, charcoal is only used in a small way; in Russia the refiners use a similar sugar. The process of sugar refining, therefore, in those countries is quite simple.

In this country, on the other hand, the refiner dealt at one time with very low, brown sugars, from Brazil, Manilla, India, even China occasionally, and also with the excellent medium class of muscovado sugar from our West Indian colonies. To refine these sugars large quantities of charcoal were used, a certain proportion of pure white sugar was turned out, and the rest was yellow sugar, greatly in demand as a cheaper form for consumption among the larger class of the population. This was as it should be, and the yellow sugar produced was a very superior article of its kind, and quite unique in the sugar refining industries of Europe. It was a speciality of the British market. The American refiners have learned their lesson from us, and make all kinds for all classes of consumers.

This clearly shows that in studying the art of sugar refining we have to examine two separate industries. Our refiners, working the lower class of sugar, and turning out a considerable percentage of yellow sugar, were content, in the first place, to dissolve the sugar in "melting pans" armed with stirrers, and to run the solution through bags to catch some of the impurities. The clear liquor then went on to the charcoal filters: large, vertical, cylindrical vessels packed with animal charcoal. The liquor, entering brown, came out white at first, then pale yellow, then darker yellow. Numbers of these vessels, containing tons of charcoal, had to be used for the purpose. As soon as the colour of the liquor from the charcoal had deteriorated to a certain point the charcoal cistern was washed out, and the charcoal went to the kilns to be reburned in order to restore to it the power of absorbing colouring matters and other impurities. The liquor was ready for the vacuum pan, and the crystallization and subsequent "curing" of the *masse-cuite* in the centrifugal machines

was carried out as already described. The syrups were filtered again and produced, in conjunction with a certain quantity of the lower coloured liquor, the yellow sugars. Roughly described, this was the practice in most British refineries, except those few which made loaf sugar. Mr. James Duncan, the greatest British refiner in the sixties and seventies, in conjunction with his partners in Greenock, hit upon the happy idea of boiling the yellow sugars at a very low temperature, and thus producing a much finer article with a delicate primrose tint, and holding within its granular structure much more syrup than yellow sugars had previously contained. The sugar fetched a much higher price, and the process enabled the refiner to turn out very little treacle, in some cases none at all. This again was a new departure entirely unique and practised only in British refineries. The United States refineries followed our example, but on the Continent no such sugar is known. Mr. Duncan introduced the new method to London by building a large refinery on the banks of the Thames, and was the head of the industry for many years.

The great fault committed by British refiners was entirely to ignore the value of a defecation process to precede the bag-filtering of the raw brown liquor. They threw the whole burden of the work on the filter bags and the charcoal. Then came the new king of the sugar refiners, the late Sir Henry Tate. He saw the point and looked for some good process of defecation. He found it in the discovery of Boivin and Loiseau, of Paris, and did not hesitate for a moment. He had been working on the Scotch system in Liverpool; he handed his house over to the Frenchmen, substituted French for English machinery, and at once made his fortune. He got a great increase in the percentage

of white sugar and reduced the use of charcoal to such an extent that his loss of weight—an important item in the cost of refining—was reduced to a minimum.

Since then other methods for defecating the raw sugar before filtration have been introduced, lime and phosphoric acid, for instance, creating a precipitate which carries down with it the gummy and albuminous impurities of the sugar.

This precipitate is now removed by filtration through what are known as filter presses instead of through the old Taylor bag filters. These presses of various types, such as the Johnson, the Sweetland, and the Vallez, permit the use of Kieselguhr as an aid to filtration, and brilliant liquors are obtained more efficiently and more economically. Their work is also facilitated by the fact that nowadays all refiners purify by "washing" their raw sugar before it is melted and filtered.

The raw sugar is mixed in a stirring machine with syrup, and then flows to a battery of centrifugal machines above the melting floor, where the crystals of the raw sugar are separated from the syrup and impurities which surround them. Here, again, is a system which results in the production of a larger percentage of white sugar. In this country the resulting syrup from this preliminary washing is filtered over charcoal and boiled in vacuum pans into fine syrups or into a good raw sugar, which, in its turn, is dried in centrifugal machines and sent to the melting pans.

This is only a brief outline of the different methods in different countries, but it is sufficient to indicate the varying ways of refining sugar, and how the demands of the consumer are applied, whether those demands come from our millions, who consume annually about 90 lbs. per head, or from those countries who do not consume half that quantity.

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Nowadays white sugar has become so cheap that the public do not demand so much low-priced yellow sugar as they used to do. The consequence is that the British refiner finds it well to use a higher class of raw sugar. For some forty years, up to the outbreak of the Great War, he had an abundant supply of good, strong, and fairly clean raw beetroot sugar, and that is what he chiefly used. So much so, in fact, that at one time there were only one or two refineries in the Kingdom who could guarantee that their sugar was "Pure Cane." As far as this country was concerned, beetroot had established nearly a monopoly.

The reader may perhaps wish to know how the Scottish refiners managed to boil their yellow sugars at a low temperature. The vacuum pan has already been described, but the method of condensing the vapour rising from the boiling sugar has not been given in detail. It used to be done by interposing a jet of cold water in the course of the wide pipe which goes from the neck of the pan to the air pump. This condensed the vapour and thus helped to increase the vacuum. The air pump took away the water of this condenser as well as the condensed vapour. This pan would boil at about 160° F. But to boil at 140° F. required a much better vacuum. This meant that the pan and its connections must be very air-tight—that is, very well made—that the air pump must be very powerful, and that the condensing power must be greatly increased. This was done by making a condenser with a vertical pipe the length of a column of water held up in a vacuum tube by the pressure of the atmosphere. Under these conditions a larger condenser could receive a plentiful flow of cold water, because the water would flow away down the pipe instead of through the air pump. The water was scattered about the inside of the condenser

in such a way as to present the largest possible surface of cold water to the hot steam. The condensation was, therefore, rapid and thorough, and the vacuum greatly increased. With these pans they could boil easily at 140° F. or even lower, the boiling went much faster, less steam was necessary, and the product was quite a different article. Even the syrup which surrounded the grains of sugar was of a delicate primrose hue instead of a dirty dull yellow. This has now been brought to such perfection that some of the soft yellow sugars are nearly white.

As to the lower yellows, they are not much wanted now, and, therefore, a new method is adopted in some refineries with regard to that stage of the refining process. Instead of going to the expense of boiling and curing these sugars, the syrup from which they would have been made is partly transformed into "invert sugar" and becomes a "golden syrup" of very superior quality and great beauty. It is of the palest golden tinge and perfectly bright and transparent, so transparent, in fact, that if served up in a cut glass dish the pattern on the bottom of the dish shines out even more brightly than if it only contained water.

There is also a very large sugar refining industry devoted to the production of "invert sugar" for the brewers. The processes of purification are carried out just as strictly as in ordinary sugar refining, perhaps, even more so, and then the whole mass of sugar solution is changed into invert sugar, and becomes a clear, bright syrup, very sweet, and best suited for the brewer.

The sugar loaf has disappeared in this country, and "Cube sugar" has taken its place—a very excellent improvement, the only objection being that if you seek in the sugar basin for a smaller lump you have difficulty in finding it. The production of the old sugar loaf

was a long, tedious, and expensive operation. The boiled mass from the pan was filled into the loaf moulds. When the mass had set firmly the moulds were hoisted to an upper floor where they stood to drain off the "green syrup." There had to be many floors to accommodate these regiments of loaves. When the syrup had drained off, a white saturated solution of pure sugar was poured on to the face of each mould, and this operation was repeated until the loaf became white from top to bottom—a work of some days. The fine syrup from this washing was kept separate from the green syrup as it contained more sugar. The loaves were then knocked out of their moulds and trimmed up, and then came more hand labour in putting them in the stove, a heated chamber running from top to bottom of the tall factory and with doors opening into each floor. Those loaves which had already become dry had also to be handed out of the stoves—very warm work—neatly enveloped in paper ready for delivery, and stacked up in the warehouse till called for.

Compare with this long and laborious process the making of cube sugar. For the loaf mould are substituted moulds made to fit into the circumference of a large and very strong centrifugal machine. They are divided by plates into a series of narrow chambers the thickness of a cube, and the full depth of the mould. The boiled mass from the pan is run into these moulds and, when the mass has solidified, the moulds are ranged round the inner circumference of the centrifugal machines which quickly throw off the green syrup. The white liquor is then applied, and immediately thrown off, the moulds containing large, flat, narrow slabs of white sugar. These slabs are ranged on carriers which travel up through a heated chamber, and come down again dried in a few minutes. They go to the cutting machine

where guillotine knives cut them up into cubes ready to be packed in boxes and delivered to the buyer. The name of Eugen Langen, of Cologne, the inventor, ought to be remembered, as he was the inventor not only of this great revolution in sugar refining but also of the gas engine. To see Langen's beetroot sugar factory at Elsdorf turning out fine cube sugar straight from the beetroot juice was a treat for anyone who appreciates the pleasure of seeing things well done; everything clean, everything tidy and handy, no mess on the floors, and a complete chemical control of all the operations.

CHAPTER VIII

THE CANE INDUSTRY

BEFORE reading this chapter, reference should be made to Table I in the Appendix, which gives the production of cane sugar throughout the world—country by country—for three years, together with the estimates for the year 1931–32. This table includes the somewhat imaginary figure of 3,100,000 tons as the production of British India. It is unfortunate that this figure should now be included in the statistics, making comparison with former years misleading and erroneous. The official estimate of the Indian sugar crop is based on an estimate of the number of acres planted, and assumes that an acre will produce 1·25 tons of sugar. But it is well known that a quantity of sugar cane is consumed in the form of cane ; it is also known that the production of sugar in India is of a very primitive kind, and that the sugar produced contains not much more than 50 per cent. of extractable pure sugar. This sugar, in the raw state, is consumed locally by the natives, and has no relation to the modern kind of sugar imported into India for the consumption of the upper classes. The inclusion of this purely native production in our annual statistics of the world's supplies is, therefore, unnecessary and misleading. It has already led to our present statisticians pointing to the remarkable increase in the world's production of cane sugar at a particular period, forgetting, or not knowing, that the apparent sudden increase at that time was caused by the sudden inclusion of a vague estimate of India's production. This discrepancy can be detected in the table given in Appendix III.

We will take the countries in their order and say a few words about some of them.

Louisiana is a country not absolutely tropical. They have occasional frosts. In spite of drawbacks the industry is carried on now in a very scientific way and with good energy and perseverance, but it would find it difficult to compete with more favoured districts if left to free competition. It is, luckily, one of the United States, and, therefore, its sugar enters the markets of the United States free of duty, which at present is a bonus of about 9s. 6d. per cwt. Concentration of work in Louisiana has been extensive. Small factories have given place to large ones, imperfect work has made way for modern improvements. Before the Civil War, the production reached, in 1861-62, 235,856 tons. During the war it fell, in 1864-5, to 5,331 tons, and did not show much recovery till 1878-9, when it reached 100,000 tons. In 1893-4 it got up to its old level, 250,000 to 300,000 tons. In 1904-5 it had the exceptionally large crop of 355,530 tons. The preferential position of the States, Territories, and Protectorates of the United States in the home market has already been explained in Chapter II. The effect of this stimulant, in bringing fresh capital into the industry, was so striking that it soon became evident that before many years elapsed the United States would receive all its sugar supplies from these sources. This forecast came true in 1915, and is a remarkable instance of the effect of preferential duties in attracting capital and thus enabling a country to be independent of outside supplies. Louisiana was not, like the others, stimulated to increase her production, but she was kept alive by the preference. That so old-established an industry should have kept pace with the times shows that it deserves to be kept alive.

Porto Rico, in 1898 annexed by the United States, has now free entry into those markets ; and, as it enjoys the advantages of a really tropical climate and good soil, it is increasing its production very rapidly, which also means putting in all the latest improvements and doing everything on a large scale. The planters have been investigating matters in Java and Hawaii, being ambitious to get something like the same yields of sugar to the acre. They declare that already their agriculture is superior to that of Cuba. Porto Rico's remarkable progress under preferential treatment is a sufficient object lesson how to attract capital to a home industry. American, British, and French capital poured in, and we see the result. In the Spanish days, Porto Rico's crop was round about 50,000 tons of muscovado sugar. In 1901-2 it rose to 82,000 tons ; in 1903-4 to 130,000 tons ; in 1908-9 to 258,000 tons ; and in 1931 to 835,000 tons—fine centrifugal raw sugar polarizing 96 and above. This remarkable increase will continue. Irrigation is being carried out on a large scale, bringing in large tracts of new land. Labour is plentiful and cheap, and there is nothing to complain of in the climate or the land. This object lesson is not confined to the selfish interests of the country concerned, it confers a world-wide benefit—more land cultivated and more food for the people. We now know, to our cost, that the opposite policy—*laissez-faire*—means less land cultivated and less food for the people.

The Hawaiian or Sandwich Islands have enjoyed a duty free market in the United States for many years and have enormously developed their industry. They grow immense weights of cane to the acre, and as they extract the sugar well their production of sugar to the acre exceeds even the remarkable figure now attained in Java. The cultivation is mostly carried on with

irrigation and, no doubt, the thing is done in first-class style. In 1857 the islands produced 313 tons of sugar, and had increased, in 1876, to 11,640 tons. The reciprocity treaty of 1876 admitted " Sandwich Islands sugars " into the United States free of duty. But it was the annexation to the United States, in 1898, that gave the finishing touch to the feeling of confidence in the future. That year the crop was 229,414 tons ; since then it has more than doubled. Perfection in machinery, cultivation and irrigation have done the rest. In 1907 two of the four islands produced an average of 5·6 tons of sugar to the acre. A third got an average yield of about four tons. Hawaii, the largest, was content with the excellent yield of 5·7 tons to the acre. Dr. Prinsen Geerligs tells us that the quality of the cane surpasses that of any other cane-growing country. The juice is the richest and the purest. The cane contains frequently from 16 to 17 per cent. of sugar. The cane mills, as well as the rest of the machinery, are the best that can be had, and they succeed in obtaining 95 per cent. of the sugar in the cane. The sugar yield of cane is extremely high. Yields of 12½, 13, even 14 per cent. are quoted, the average being over 12½. These figures are unsurpassed elsewhere. This is another and still more striking example of what can be done when capital is attracted to an industry by preferential treatment. Its progress since 1910 shows further large expansion. In 1910 the crop was 463,000 tons ; in 1916-17 it was 579,302 tons ; and in 1931-32 it is 900,000 tons.

Cuba is the place on which the eyes of the sugar world are now constantly fixed. The preference enjoyed by Cuba in the markets of the United States is only 20 per cent. of the duty, but this has been enough to give a great impetus to its sugar production. American

capitalists have been attracted even by this modest bonus, and are exploiting the large and fertile island very thoroughly. Cuba, before the revolution and the subsequent American war with Spain, managed to get up to a million tons of sugar a year ; but during her troubles the crop fell off to a comparatively insignificant figure. In 1897 it was under 300,000 tons, but in 1903 had recovered to 1,003,873 tons. Then the preference in United States markets began to tell rapidly. In 1909 the crop was 1,521,818 tons ; in 1913 it reached 2,428,537 tons ; in 1916, with another great jump, it reached 3,007,915 tons. The crop of the following year was correctly estimated at over 3,500,000 tons, but rebellion in the Eastern provinces destroyed the odd 500,000 tons. This wonderful and unparalleled increase in production is an instructive instance of the virtue of even a small and reasonable preference in stimulating the investment of capital in industrial production for the permanent benefit of the country—both producers and consumers. Cuba is undoubtedly the queen of cane sugar-producing countries, though Java runs her very close. Perhaps the most striking point in the Cuban sugar industry is the size of some of her factories. A few hundred tons of sugar used to be considered a fair or even large out-turn for a sugar factory in the tropics, but now we find in Cuba that the majority of the factories turn out from 10,000 to 100,000 tons of sugar per factory in the season. One effect of the enormous crop of sugar in Cuba has been that the rush of sugar to New York during the heaviest part of crop time has frequently depressed prices far below European parity—a curious instance of preferential duties being a benefit even to the consumer. The crop for the year 1931–32 is limited by the Chadbourne Plan to 3,000,000 tons.

The British West Indies and British Guiana were very hard hit by the beetroot competition, and in some of them sugar has given place to other industries. Barbados still holds its own, but is now substituting modern factories and centrifugal sugars for the good grocery muscovado kinds for which it was once so celebrated. Trinidad makes some very good sugar, so does Demerara, a British sugar colony which has for long been in the first rank as a producer of choice sugar. Large factories were erected in many of the islands. The first were in the islands of Trinidad, Antigua, and St. Lucia; followed by several in Jamaica. There is now one in St. Kitts. The machinery is first-class and comes from British makers, who are now very up to date and know everything that is to be known about modern sugar production. The survival of the industry in our oldest colonies is a matter for much congratulation, especially when it brings a large increase of work for British engineers. The low value of sugar during 1931 caused serious losses to all producers, and only the Preferential Duty here made it possible for them to continue.

Before leaving the subject of our West Indian Colonies, something more must be said about their condition before and since the great fall in the price of sugar in 1884-5, caused entirely by the over-production of European bounty-fed sugar. Barbados and Trinidad seem to have held their ground fairly well: the first on account of the popularity of its fine grocery muscovado sugar and of its syrup, its good soil and climate, and its large population; the second on account of its very good soil, its prosperity in other respects, and its fairly well-equipped factories, which ought, however, to get a better yield of sugar from the cane than they do now. The islands of Grenada, St. Vincent,

and Dominica seem almost to have abandoned the crop, and Jamaica to have considerably reduced it. The sugar produced by Jamaica was, from the point of view of the British refiner, very superior to any other raw muscovado sugar, except perhaps that from St. Kitts. The juice must have been very pure to produce such sugar, or else the method of manufacture must have been very superior. But now Jamaica has launched out into the modern central factory system and produces the usual "centrifugal sugar, basis 96 polarization." The island's production used to range from 25,000 to 35,000 tons. After the great fall in price in 1884-5, it gradually dwindled down from 18,000 to 20,000 tons. In 1931-32 it produced 65,000 tons.

The French West Indies were once in the first rank, but they have not kept pace with the times. They were at one time well equipped, but now their machinery, especially in the evaporating department, is out of date. They have for a very long time turned out a kind of white sugar, the kind for which there is a demand from the refiners in France. Their working expenses are high, and labour is scarce and indolent. They stand still at a production of about 30,000 to 40,000 tons from each island.

The small French island of Réunion, a neighbour of Mauritius, suffers from want of labour. If that could be obtained, the industry would flourish.

The island of St. Domingo seems to be progressing, though not favoured with any artificial stimulus. They made 60,000 tons in 1907-8 ; 80,000 tons in 1908-9 ; and 90,000 tons in 1909-10. Since then, as may be seen in Table I, the production has increased to 365,000 tons in 1931-32, and is still increasing. The factories, mostly American, are modern and up to date.

Mexico is doing well and putting up some first-class factories. They get long prices in their own markets, thanks to an excessive Customs barrier, and do not yet make much of a surplus for export. Here political unrest is the great trouble. The production increased rapidly from 75,000 tons in 1900 to 160,000 tons in 1911. Since then, internal quarrels reduced the sugar production to 50,000 tons, but in 1931-32 it had reached 200,000 tons. With peace at home, sugar production will flourish and increase rapidly.

Peru, Brazil and the Argentine are producers on a fairly large scale, but parts of Brazil are sadly behind the times. They can get very good prices at home when they make no surplus, but when they are obliged to export they find it difficult to keep up home prices. They tried to form a combination for that purpose but it broke down. The country could produce a very large crop if it were not that capital and labour are wanting. There are, however, several modern factories in Brazil, trying to reform the industry.

Peru has a great future if all goes well. Irrigation, combined with good soil and climate, and canes which produce rich pure juice, only require up-to-date factories to enable Peru to compete with Java and Hawaii in the amount of sugar produced per acre. The rich land between the mountains and the sea, coupled with the valleys and streams which run from the hills to the coast, give a perfect arrangement for universal irrigation. The climate is almost rainless, so there is no variety of season, and sugar can be produced and reaped all the year round. It takes nearly two years in this dry climate for the canes to mature. There are many good factories, but the machinery is not powerful enough yet to get a large yield from the canes. The production of canes per acre is large, and 3 tons

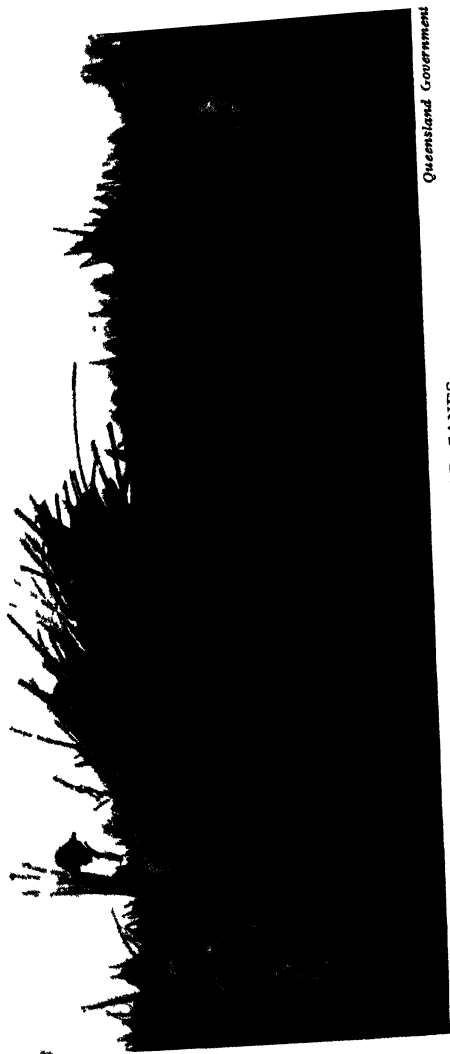
of sugar per acre represents at present about the average yield. In 1894 Peru produced 74,000 tons of sugar ; in 1904, 156,000 tons, in 1914, 262,000 tons, and in 1931-32, 514,000 tons. Previous to 1894 the industry suffered greatly from the European bounty-fed competition, and from war and revolution. Labour is sufficient ; all that is necessary for good progress is political rest and some encouragement to the investment of fresh capital in the industry.

Argentina has a heavily protected home market, and is not likely to become an exporter owing to high cost of production.

British India is supposed to produce the official figure stated in the list, but production is so primitive and scattered that it must be difficult to arrive at any definite estimate. It is satisfactory to read, in a recent official report, that "steady efforts are being made by the Agricultural Departments to improve the cultivation and the processes of extracting cane juice and of sugar manufacture." India, in spite of her large home production, is a considerable importer from Mauritius, Java, and even Europe.

Java is a superb instance of success, the result of individual energy and intelligence stimulated only by science and organization. But the island has one advantage which is not always to be found in the tropics, plentiful, good and cheap labour. They have always made the finest raw sugar in the world, but now they have added to this a considerable production of white sugar, for which they find a constantly increasing demand in British India where it competes with our old sugar colony of Mauritius, and where it is gradually supplanting the quantities of European beetroot "granulated" which were for many years "dumped" in India.

In 1916-17 Java produced 1,596,174 tons, and the



Queensland Government

CARTING SUGAR CANES

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crop 1931-32 is estimated at 2,500,000 tons. At one time the Government limited the production in order that sufficient rice and other crops might be grown to feed the people. But since then more land has come under irrigation and continues to do so. This irrigation is now almost universal, and the water from the rivers deposits a fertilizing slime which furnishes sufficient potash and phosphoric acid to the soil. As the cane crop is alternated with rice or other food crops it gets the full benefit of this fertilizing deposit. When the "Sereh" disease threatened destruction to the canes in 1902 cuttings were imported and the "Sereh" was stamped out. Seedling canes were also raised and selected varieties propagated and cross-fertilized, until at last Java has arrived at the remarkable product of 42 tons of canes to the acre, *as the average for the whole island.*

The increase in the production of sugar per acre is most remarkable. The accurate figures given by Dr. Prinsen Geerligs show that in 1893-4 the average production was 2.812 tons (of 2,240 lb.) per acre, quite a remarkable figure in those days. In 1897-8 it had increased to 3.571 tons; in 1903-4 to 4.058 tons; in 1910-11 to 4.302 tons; and in 1925 to 5.1 tons. The only country that can beat that figure at present is Hawaii. Dr. Prinsen Geerligs does not put any limit to his anticipation of the further progress of the industry. The production per acre is still rising; cultivation, the selection of the right kinds of cane for different soils, improved methods and greater rapidity in juice extraction and treatment, all contribute to this result. The work of cross-fertilization in finding new varieties of cane goes on with redoubled ardour and promises great things in the future. Increase of cane crop coupled with increased richness is what they aim at. It is found

that increased quantity of juice in the cane is always accompanied by increased purity of the juice. More juice gives more sugar, and increased purity gives still more sugar. The area in Java, moreover, which will be devoted to sugar goes on increasing. For some time it stood still, because other crops were regarded by the Government as essential to the well-being of the population, but now there is permitted a greater expansion. Fresh ground is being prepared everywhere for the cane crops, together with new systems of irrigation, so that eventually more arable land will be available for the sugar manufacturers, who are quite ready to absorb it. In Dr. Prinsen Geerligs' opinion, therefore, there is every expectation of a steady and perhaps sudden extension of the Java sugar industry.

The history of the sugar industry in Formosa and its probable future have already been described and explained in sufficient detail in Chapter II.

The Philippine Islands are now under the wing of the United States, and the American Government has ordained that all sugar from that country shall be admitted free of duty into the United States markets. Under ordinary circumstances the result would be that American capitalists would exploit this new field for enterprise, erect monster factories, as they have done in Cuba and Hawaii, and create another vast centre of sugar production. But the interest of the United States' own sugar industries in Louisiana and in the beetroot districts of the North had to be considered, and it was decided that the preference must be confined to the produce of existing factories, mostly in native hands, and thus the hope for the investment of capital in the new venture was for the moment checked. But now, American capitalists have acquired large tracts of

land for the purpose of sugar production on an extensive scale.

Dr. Prinsen Geerligs says : " As regards the prospect of the cane-sugar industry in the Philippine Islands, all forebodings point to gigantic progress in the near future."

In Australia a good deal of sugar is produced in Queensland and a little in New South Wales. The refusal to allow coloured labour to work in the tropical parts of Queensland, although wise, is a serious drawback to any extension in that direction. In the present sugar-growing districts, where white labour is possible, it is found to be expensive and in other ways difficult. There has been a good deal of Government control, which adds sometimes to the difficulties of the industry. The cost of production is high, and therefore requires liberal preferential treatment to enable producers to make both ends meet. Central factories are now universal, but the cane planting leaves much to be desired. The industry began in a small way in 1864, and by 1883-4, 152 factories produced 36,000 tons of sugar. In 1910-11, 54 factories produced 207,000 tons. The production is about two tons to the acre.

New South Wales produces an average of about 20,000 tons. The total production of Australia in 1914-15 was 246,408 tons, and in 1931-32, 615,000 tons.

Our old sugar-producing colony of Mauritius has had many struggles. They made splendid sugar in the old days, only beaten by Java for quality. They do still better now because they make a large quantity of white sugar for the Indian market. But machinery which was at one time superior at last became antiquated. Then came low prices, and a great disaster

followed. The whole of the cattle were suddenly destroyed by a terrible disease. This deprived them, at one stroke, of their only means of haulage. This, coupled with a destructive cyclone, brought them to the verge of despair. They wanted money for light railways to draw the canes to the mill, and if they did not get it their crop would be lost. The Colonial Office came to the rescue just in time and the danger was averted. Then prices improved, hope began to revive, what the French call concentration of work was carried out, old small factories were closed and large "centrals" established, and they began to breathe again. Irrigation has been carried out on a large scale, the railways have been improved, factories are now working on modern lines, and with the aid of the Preferential Duty things will progress as soon as sugar resumes a normal value. Labour is a difficulty, as with our colonies in the west, and it would be well if capital were more abundant, but, barring cyclones, prospects are good. Labour was originally imported from India, but as the Indians settled down permanently as small planters, imported labour became unnecessary. Their production of cane per acre is, however, very inferior to the out-turn of the large planters. The average richness of the cane is a little under 14 per cent., and the yield in the factory about 10.5 per cent. The average crop of cane per acre (30 tons plant and 20 tons ratoon) is about 23 tons, including the inferior crop of the small Indian planter. The canes take from twelve to twenty-two months to ripen, according to the climate of the district. From 1884 to 1897 the crop varied from 100,000 to 150,000 tons. From 1898 to 1912 it ranged from 150,000 to 250,000 tons. In 1931-32 it is 175,000 tons. Seventy years ago we imported large quantities of Mauritius sugar; but when the European bounties were in full

operation, Mauritius only sent a very small quantity to Europe, mostly after-products. Imports fell as low as 7,000 tons, but recovered to 50,000 tons after the abolition of the bounties. In 1915 (war time) she sent us 111,875 tons of raw sugar and 85,118 tons of refined. India now imports annually 100,000 to 150,000 tons of white Mauritius sugar.

CHAPTER IX

THE BEET INDUSTRY

WHETHER the sugar cane came originally from the East and was carried from one country to another till at last it arrived in the Western Hemisphere, or whether it was indigenous on both sides of the world cannot be definitely decided, but there is little doubt that it was carried from China to India and Arabia, and afterwards introduced by the Arabians into Persia, Africa and Spain. It was the Spaniards who started its cultivation in the West Indies and America. India is said to have produced sugar as early as the seventh century—a rare and costly article in those days.

The date of the first production of sugar from the beetroot, on the other hand, is very definite. A German chemist, Marggraf, in the year 1747, was the first to call attention to the fact that the juice of the beetroot contained sugar identical in composition and properties with cane sugar. But it was not till 1799 that this discovery was put to practical proof on a working scale. A pupil, or follower of Marggraf, Francis Karl Achard, invented at that time a method of extracting sugar from the beetroot. Great interest was taken in this idea for a new agricultural industry, and the King of Prussia gave substantial help in the erection of the first beetroot sugar factory in Silesia. Other factories followed, not only in Prussia but also in Bohemia. In 1811 France took up the new industry and from there it spread to other countries. Napoleon gave it a great impetus, seeing at once the advantage of producing sugar at home, and voted large sums of money and considerable tracts of land for the encouragement of the new manufacture. The blockade had raised

sugar to famine prices, so the new French factories flourished. Forty were in operation in 1812 and produced about 10,000 tons of sugar. But when the blockade was raised the price fell and the new venture had a bad time. About 1830 there was a fall in the price of corn and the farmers turned again to sugar beet. By the year 1854 Europe produced something under 200,000 tons of beet sugar. Ten years later the figure went up to over 500,000 tons. In 1871 it exceeded a million tons. Ten years later it was approaching two millions. The cane sugar industry saw itself seriously threatened. The fear turned out to be well founded. The time came when half, and even two-thirds, of the visible sugar production of the world (not reckoning the then unknown production of India) was produced, not from the sugar cane but from the sugar beet.

To begin with a comparison between the progress of France and Germany in the production of beetroot sugar—an instructive chapter in a very remarkable story. In 1871, France was the leader in the industry; she produced 284,444 tons, while Germany produced only 186,442 tons. But while the German Government, as is their practice, began to foster the industry in a far-seeing and rational way, the French Government allowed their great agricultural and industrial sugar producers to shift for themselves. The German producer was charged with his sugar tax in the form of a duty on the weight of the roots. The roots were estimated to yield a certain percentage of sugar, and were charged accordingly. This was—and was intended to be—a strong incentive to the farmers to grow richer roots, and to the factory to get more sugar out of them. The system, as usual in Germany, was a great success. The roots grew richer every year and the machinery for extracting and completing the sugar was constantly

improved. Scientific methods progressed and flourished because they brought larger profits to both farmer and manufacturer. In France, on the other hand, the factories were under the strictest excise supervision, every ounce of sugar was checked and noted, and had to pay the full sugar duty.

The result of these two opposite systems was that while France produced no more in 1884 than she had done in 1871, the German production had gone up from 186,000 tons to 1,123,000 tons. The French producers saw that this meant ruin if allowed to continue. The percentage of sugar extracted from the roots had gone up in Germany from 8.28 per cent. to 11 per cent., while in France it remained at the old figure, below 6 per cent. The French Government at last realized their mistake and hastened, in 1884, to rectify it by imitating Germany. They adopted the system of duty on the roots, and it was a duty based, of course, on a very low estimate of yield. The effect was instantaneous. Better seed was sown in France, better methods of manufacture were adopted, the diffusion process was substituted for the old hydraulic presses, and the yield of sugar began to rise by leaps and bounds. From 6 per cent. it soon went to 7, 8, 9 and 10 per cent. But as the French producers were allowed the full drawback on exportation, although they were paying only a small fraction of the duty on the sugar they produced, the revenue began to show a great and constantly increasing loss. The French Government, unlike the German, had greatly overdone the dose of stimulant, and they had to begin to take precautions. They found that the sugar industry was making an enormous profit out of the new system. In the first year the manufacturers pocketed 25,000,000, francs; in the third year, 1886-7, their profit had risen to 91,966,437 francs,

or £3,678,657. These are official figures. The Government were obliged to check this drain on the Exchequer. In 1887 the legal yield was raised, and the excess yield, instead of going free of duty, was charged with a modified tax. For two years the large profits were slightly reduced, but in 1889 they were again over 90,000,000 francs. There was then another raising of the legal yield and the profit was again reduced, but began to recover as the yield of the factories went on increasing. In 1893 it was 39,000,000 francs, but in 1896 it had reached 54,000,000 francs. During this period, 1884 to 1896, the yield of sugar from the roots had gone up from 6 per cent. to 11 per cent., and the French crop had increased from 265,000 tons to 668,000 tons.

Turning again to Germany, the yield of sugar from the roots, which was, in 1871, 8·28 per cent., had risen by 1884 to 11 per cent. They had thus got more than ten years start of their French competitors. But in 1896, when the French managed to reach a yield of 11 per cent. the Germans had reached a yield of 12·66 per cent.

It must be borne in mind that in Germany, as in France, though the duty only struck a portion of the sugar produced, the full drawback was allowed on all the sugar exported. This was an enormous incentive to production and exportation and a serious loss to the revenue. The German Government saw that their wise and moderate system had about done its work. In 1888 they took steps gradually to make a transition from the system of duty on the roots to the evidently more rational method of charging the duty on the sugar actually produced. In 1892 this period of probation was accomplished, the factories were under full excise supervision and all the sugar paid the duty. But the German Government were wide awake to what was

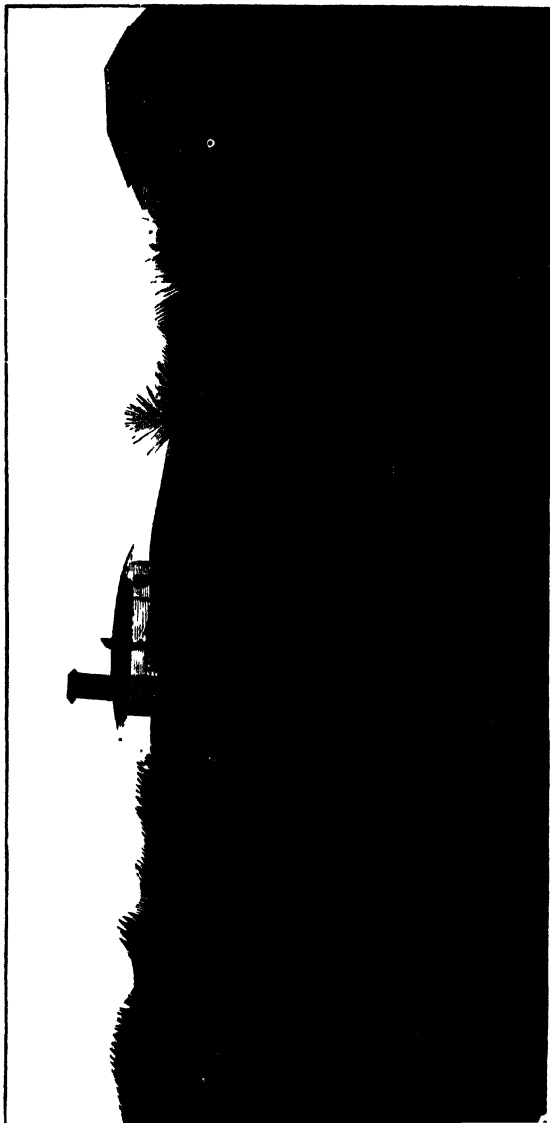
going on in France, so they presented the manufacturers with a temporary direct bonus on exportation, which was to be abolished as soon as France and other countries ceased to give direct or indirect help to their sugar producers out of the revenue. Here again the German Government were quite wise and reasonable.

The French Government followed suit in 1897; but again they made a mistake in overdoing it. They abolished the duty on the roots and levied it, very properly, on the actual sugar. But instead of coming to terms, in conformity with the German friendly overtures, they disregarded the invitation and gave a bonus on exportation just double that of Germany. This, as the French Minister said, was a defiance and a challenge.

The German production had now increased to 1,821,223 tons, nearly three times that of France. Their revenue from sugar had gone down from 63,249,000 marks in 1875 to 33,624,000 marks in 1886, and 14,677,000 marks in 1887. Then they began their reforms and the revenue recovered to an average of about 76,000,000 marks in the years 1889-92. After that the full duty on all the sugar was secured, and the revenue went up to 84, 92 and 99 millions of marks for the next three years. The stimulus had done its work, for not only had the German production gone up to nearly 2,000,000 tons but their exports of refined sugar, which were 5,809 tons in 1871, had reached, in 1888, when the reforms began, 150,341 tons, and in 1892, when the reforms were completed, 270,607 tons. The direct bonus on export, which was then substituted as a temporary measure, brought the exports of refined sugar up to 503,928 tons in 1897. The German exports of raw sugar were 491,176 tons in 1883, and remained much the same till 1894, when they rose to 609,662 tons; in 1896 they were 760,657 tons.

This is a striking picture of the progress of an industry under a judicious, paternal Government.

France was injudicious, but Austria was still more so ; and yet their system laid the foundation for an enormous and flourishing industry. The Austrian sugar duty was levied in a peculiar way. It professed to be a duty on the roots, but instead of a careful weighing of the roots, as in Germany, the quantity of roots was roughly estimated according to an official supposition of the capacity of the apparatus of the factory. It was, in fact, an estimate within an estimate. The Austrian manufacturers were, therefore, not only stimulated to grow rich roots and to get the utmost quantity of sugar out of them, but also to make the apparatus of the factory capable of working more roots than were estimated by the Government. In 1871 the Austrian engineering works were full to overflowing with work for the sugar factories, making, among other things, diffusion vessels which should turn out more juice per day than those then in use. There were also, in those days, some factories still working with hydraulic presses. They were a curious sight. The work was carried on at such high speed, in order to do more than the estimated quantity, that the place was a perfect pandemonium, and the floor covered with juice owing to the hurry and bustle of the establishment. The Austrian Government were losing revenue to such an extent that it seemed probable that they would soon cease to receive anything from the sugar duty. This proved to be only too true. In 1867 the net revenue was 5,363,159 florins. By 1874 it had dropped to 1,742,324 florins, and in 1875, while the gross revenue was 9,337,435 florins, the drawback allowed on exports amounted to 9,472,991 florins, so that the sugar duty produced an actual loss to the Exchequer of 135,556 florins. They remedied this disastrous state of



QUEENSLAND—CARRYING CUT CANES TO THE FACTORY

things by insisting on a fixed minimum revenue with a gradual yearly increase. This checked the exports to a certain extent and the manufacturers loudly complained. In 1888, therefore, the whole system was abolished and the duty was levied on the actual sugar produced. The Government followed the example of Germany, and gave a temporary direct bonus on exports, to be abolished when a general agreement with the other countries should be arranged. The manufacturers enjoyed the certainty of 9,000,000 florins per annum and were satisfied. The stimulus to production continued and exports rapidly increased.

Belgium and Holland levied the duty neither on the sugar nor on the roots but on the density of the juice. No one knows how much the manufacturers made out of this, because neither the quantity of sugar produced nor the quantity consumed has ever been discovered.

Russia desired to have a flourishing beetroot sugar industry, and after many vicissitudes hit upon a system which thoroughly answered the purpose of giving the necessary stimulus. The Russian Government, in 1894, took the matter into their own hands. They fixed (1) the quantity of sugar necessary for home consumption; (2) the maximum price to be charged to the consumer, a price, after deducting the duty, about double that in outside markets; (3) the quantity of sugar to be kept in reserve, a portion of which was to be thrown on the market if prices rose above the fixed limit. Each manufacturer was allowed to send into consumption a fixed quantity of sugar, and then his surplus production was apportioned to the home market in proportion to his total production. Here was not only a security for good profits in the home market but also a constant stimulus to over-production. Fortunately the Russian consumption, in spite of the high price, steadily

increased, owing to the constant extension of the Empire eastwards. But at times there was a large surplus to be got rid of, which had to be thrown on the outside markets and sold for what it would fetch. The high price at home maintained even then, for the Russian producer, a large average profit far beyond the natural level. This was, in fact, a "Combine" or "Cartel," established and regulated, not by the industry but by the Government, and strictly supervised by them. The details were modified from time to time, but the main features remained. The production in Russia was 159,000 tons in 1875, 475,000 tons in 1885, 679,000 tons in 1895, 1,127,000 tons in 1909-10, and exceeded 2,000,000 tons in the two following years. The year before the war, Russia produced 1,750,000 tons, but by 1916-17 the production had fallen to 1,160,000 tons.

During the war the production in Germany, Austria, and France fell considerably, as shown in Appendix II.

Turning to the exports from Germany and Austria, the former exported, in 1875, 7,245 tons of refined sugar, and, in 1897, 503,928 tons. Austria, in 1875, exported 39,887 tons of refined sugar, and, in 1897, 460,154 tons. The raw sugar exports in 1883 were: from France 42,236 tons, from Germany 491,176 tons, and from Austria 131,019 tons. From that year Germany kept up a steady export varying between 400,000 and 700,000 tons per annum. The French exports were very fluctuating, as low as 3,000 and as high as 300,000 tons. Austria was also very fluctuating, as high as 180,000 and as low as 31,000 tons. The exports of refined sugar from Austria were very high and very steady, because the profit from the duty or the bonus was so arranged as to give the turn to the production and exportation of refined rather than raw sugar.

This rough sketch of the progress of the European

beetroot sugar industry gives rise to many reflections. It has been artificially stimulated, as we see, to a vast extent, and then lost its artificial stimulus. The Brussels Convention of 1903 put a stop to it. During its progress it won the race against cane sugar and became the dominant factor in the sugar markets of the world.

The yield of beetroot sugar, per acre, is only one-and-a-half to two tons at the best. From the cane, in very favoured countries, as we have seen, the yield per acre can reach four to five tons. Then, as to skill and excellence in manufacture, the beetroot factories were at one time far in advance of the cane. The tropical industry has now learned the lesson from its European competitors, has improved its methods and goes on doing so very rapidly. But the European industry has its market almost at its doors, while the tropical sugar must sometimes travel long voyages to reach the consumer.

The Great War necessarily caused a great decrease in the European beet crop, which, however, has now reached its pre-war level. Owing to the high prices prevailing during the War the cane crop rapidly increased and is now approximately twice as great as the beet crop. Another effect of the Great War was to emphasize the desirability of producing beet sugar in England and thus make this country less dependent upon foreign sources for its sugar supply. Attempts in this direction were made as early as 1832, and continued at intervals, but all the attempts failed, largely owing to the inexperience of the farmers. In 1912 a factory was erected at Cantley in Norfolk, but owing to the War little progress was made until 1920. In 1921 a factory was erected at Kelham in Nottinghamshire, but financially both were unsuccessful until 1924, when the Government granted a subsidy on beet sugar produced in this country. The intention was to create

employment, particularly in agricultural areas, and in this direction the project has been successful owing to the high amount of the subsidy, which decreases in stages over a period of ten years, the amount being 19s. 6d. per cwt. on white sugar from October, 1924 to 1928, 13s. from 1928 to 1931, and 6s. 6d. from 1931 to 1934, the corresponding amounts on molasses containing 50 per cent. of sugar being 4s. 3·8d., 2s. 10·5d., and 1s. 5·2d. The excise duty charged on this sugar is equal to the Preferential rate charged on Empire sugar. Ten years should suffice to overcome the inexperience of those engaged in the industry, but it remains to be seen whether the cost of agricultural labour will enable the industry to succeed financially without some further form of Government assistance being granted after the expiry of the present subsidy. In this connection it may be noted that, under the existing conditions, English beet sugar is granted Government assistance much greater than Empire sugar, which receives a preference over foreign sugar amounting to 5s. 10d. per cwt. on white sugar, this representing exactly half the duty. Since 1928 the duty scale has been altered to remove injustices previously suffered by British refiners. This has enabled them to sell cheaper than their foreign competitors and thus entirely exclude foreign white sugar from this country. Since the commencement of the subsidy factories have been erected at Colwick, Bury St. Edmunds, Ely, Ipswich, Kidderminster, Spalding, Wislington, Cupar, Felstead, Peterborough, Poppleton, Allscott, Bardney, Kings Lynn, Brigg, and Selby. It must be understood that the subsidy enables the factories to pay a price to the farmer for his roots higher than the world price, otherwise sufficient roots would not be grown to keep these factories supplied. The growth of the industry can be seen from the following

figures giving the quantity of sugar produced in the years indicated: 1923-4, 13,280 tons; 1924-5, 23,915 tons; 1925-6, 51,638 tons; 1926-7, 150,196 tons; 1927-8, 182,581 tons; 1928-9, 193,783 tons; 1929-30, 291,500 tons; 1930-31, 422,728 tons; 1931-32, 291,000 tons. This latter quantity represents about one-sixth of our annual consumption and was the yield of about 234,400 acres of roots. (See Appendix XII.)

The United States, after a few unsuccessful efforts in former days, began, in 1890, seriously to embark in the industry of beetroot sugar production. Clever men made a careful study, in the European countries, of the methods of manufacture; the Department of Agriculture, and especially Dr. Wiley, the chief of its Bureau of Chemistry, rendered valuable advice, and the small beginning soon grew to large dimensions. In 1892 there were six factories, turning out 13,000 tons of sugar. In 1902 there were forty-one factories, with a total sugar production of 218,406 tons. In the season 1908-9, sixty-three factories produced 421,244 tons. In 1912-13, seventy-three factories produced 769,507 tons, expressed as raw sugar. The industry enjoys, like its sister cane sugar industry in Louisiana, the profitable privilege of entry to the home markets duty free. At present the agricultural branch of the industry is not a great success, their average weight of roots to the acre being only 8 to 10 tons. The manufacturing department, no doubt, includes many up-to-date factories, and the results will probably improve steadily year by year. Up to 1902-3, the extraction of sugar from the roots had increased from 11·4 per cent. to 12·8 per cent. In 1910-11 it was 14 per cent., in 1913-14, 14·4 per cent., and in 1923-4 15·3 per cent. Why the farmers do their part of the work so badly is not explained. In many parts, no doubt, the climate

is not so favourable as it is in Europe. The industry is, however, very sanguine with regard to the future, and we can only wish them every success in their brave determination to grow and prosper.

Canada is beginning to make her appearance in statistics as a sugar-producing country on a small scale. The history of her attempts to produce beetroot sugar is instructive and a warning. It is very much the experience of the United States over again. In 1881 the first attempt was made. We are told in a recent Report that the experiments then made could not prove anything but a failure. In 1901 four factories were started, but suffered from the usual initial drawbacks : insufficient beet acreage and incompetent factory management. The farmers were, of course, inexperienced and discontented with the price paid for the roots. The consequence was that one factory was moved to the States ; another gave up the attempt ; and the two remaining combined, in 1909, to form the present "Dominion Sugar Company, Limited." The two drawbacks were gradually overcome ; the farmer began to recognize the benefits to be derived from the crop ; and it became a known fact that, once interested in beet-raising, he very rarely discontinues. The farmer appreciates the fact that it is a cash crop. Prices have now been arranged on the basis of richness of the roots and, in fourteen years, prices have risen considerably. The Canadians have now learned the details of the factory work, and can dispense with incompetent imported "experts." In 1916 the Dominion Company completed the erection of a large beet-sugar factory to work 1,800 tons of roots a day. The plant is one of the most complete in the world, equipped with the most modern machinery and appliances that science has devised.

CHAPTER X

COMPETITION

THE remarkable and sudden growth of the beetroot sugar industry, as related in the last chapter, was stimulated in every possible way, first by a quiet, unseen but well-known system of under-estimate of the duty to be levied, coupled with full payment of drawback on exportation ; and afterwards by the payment of a direct bonus on exportation. All this the reader must have thoroughly realized from the facts just described. He must now be led, for a moment, a step further back in the history, to a time in the early sixties, when the beetroot industry was still in its youth and the dominant factor in the European sugar markets was the refiner. We made all our own refined sugar in those days, but our comfortable times were to be rudely disturbed. An invitation was addressed to the British Government to join France, Belgium and Holland in an International Conference on the sugar duties. The refiners here got no benefit from the duty and were, therefore, quite willing to have the matter discussed. It was not very clear why the other countries should desire us to join them in reforming their own tariffs. To judge from the result it would almost seem as if they brought us into the discussion in order to get our duties altered. If so, they were entirely successful. Our Government did exactly what they wanted, and kindly did it even in advance of the international agreement. This may have been magnanimity but can hardly be regarded as good business. It would have been better to wait and see how the terms of the Convention were carried out. However, it was signed and ratified in 1864, and the

only result, so far as this country was concerned, was a constantly increasing supply of loaf sugar from France and Ho'land. In five or six years the competition became serious. Many of the London loaf sugar refiners retired from business. The rest began to look into the matter and soon found out the cause of this alarming invasion. According to the terms of the Convention the duties on raw sugar were to be levied according to the colour of the sugar. There were three or four classes, paying different rates of duty, the brownest sugar in the lowest class, and so on up to the finest in the first class. The system worked quite fairly in this country, where the refiners used great varieties of raw sugar from all parts of the world. But in Paris the refiners were beginning to use the raw beet-root sugar, the quality of which was not accurately indicated by the colour. They could get sugar classed as yielding only 80 per cent. of refined which in reality yielded 90 per cent. In France the duty was very high and, therefore, the profit on 10 per cent. of sugar escaping the duty was very large. The full drawback was allowed on exportation and, hence, the refiner naturally got the full duty from the home consumer. He, therefore, got a profit of 10 per cent. of the duty on the whole of his production. After the Franco-German War, the duty was greatly increased and so was the refiner's profit.

In 1872 our markets were, consequently, flooded with loaf sugar from Paris. A general meeting of British refiners, at which every firm in the kingdom was represented, was held in London, and a Committee was appointed to deal with the subject and induce the Government to obtain a rectification of this gross abuse of the terms of the Convention. The Committee set to work with a will, but they little knew that they were

entering upon a thirty years' struggle, of which they only saw a small beginning at that time.

The Foreign Office took the matter up very willingly. It was a complicated subject, but they gradually learned their lesson and did their best. Some of the refiners began to add diplomacy to their other labours and the contest went merrily on. There were dispatches and counter-dispatches without end, but the foreigners were too clever for us.

The refiners, however, found very useful allies in a most unexpected quarter. The French beetroot sugar producers, as related in the last chapter, were under stringent excise supervision and had to pay duty on every ounce of their sugar. If anyone in France ought to have been allowed to "get a pull" out of the duty it was the beneficent agricultural industry of sugar production, not the three or four millionaire sugar refiners in Paris. The country manufacturers were naturally jealous of the favours enjoyed in Paris which they were not allowed to share, and they also saw that large exports of loaf sugar to England robbed them of good customers there and made them more dependent on the Paris monopoly. They, therefore, threw themselves into the fight with great spirit and considerable success. Members of the National Assembly were enlisted on their side and the abuses were well exposed by eloquent speakers.

The remedy proposed by the British refiners, and backed up by their French friends, was that the refineries should be under the same excise supervision as the beetroot factories. If the refined sugar was made "in bond," that is, without any duty having been paid, then the portion which went for export would require no payment of drawback, and that which went for home consumption would pay the full duty on leaving

the refinery. The cure was absolute and easy. A system which worked without difficulty in hundreds of beetroot factories could be very easily worked in three or four refineries. The arguments were put before the National Assembly with great ability and a law was actually voted for putting the refineries under excise supervision and thus getting the full duty on the sugar actually produced and paying no drawback on exportation.

This was a great triumph, and success appeared to be more than probable. Our Government urged the matter very steadily, an International Conference was held in Brussels in 1875, followed by two more in Paris in 1876 and 1877. But the foreign delegates stubbornly resisted. They proposed a compromise. "Saccharimetry," they said, would be a sufficient remedy. All sugar entering the refinery should be analysed and the duty levied accordingly. The British delegates, very properly, had no faith in this proposal as a sufficient security against clever manipulations, and held their ground firmly. The French Government shelved the Bill voted by the National Assembly for "refining in bond," and showed no great desire to protect their revenue. The Paris refiners were too strong and won the battle. There was only one British loaf sugar refiner left.

During this initial phase of the coming struggle the British Refiners' Committee induced the West India Committee to join hands with them. The West Indians saw that every ton of foreign refined sugar imported displaced an equivalent quantity of their raw sugar. It was also pointed out that new abuses, as described in the last chapter, were making their appearance in Germany and Austria, and that very soon raw beetroot sugar, enjoying the extra profit derived from a vicious

system of levying the duty, would be invading British markets on terms with which no cane sugar producer could compete. This turned out to be only too true. Not only raw but also refined sugar from Germany and Austria began to pour in, the quantity increasing rapidly from year to year.

The two industries of British refining and Colonial sugar production demanded that a Select Committee of the House of Commons should be appointed to examine the whole question. Mr. Ritchie, then member for the Tower Hamlets, obtained the Committee and presided over it with great ability for two years, 1879 and 1880. The inquiry was carried out thoroughly and was in every way—except practical effect—a great success.

The foreign delegates at the various conferences had pointed out, in view of what was going on in Germany and Austria, that it would be quite impossible for their Governments to agree to any Convention for the abolition of these artificial aids to foreign manufacturers unless the British Government would give them security, by a clause in the Convention, that they should no longer have to compete in British markets with sugar receiving similar advantages from other foreign Governments. This was such a reasonable and necessary demand that it could not be disputed or disregarded. If a foreign producer receives from his Government some gift out of the revenue which enables him to sell his produce below cost price and yet make a good profit, it is not only reasonable and consistent with common sense but also absolutely necessary, if British industry is to survive, that such a direct attack on our industries should be warded off by some defensive action. The amount of the artificial profit thus obtained could, in the case of sugar, be very accurately defined, and therefore it would be easy to countervail it by an

equivalent duty. The sugar would then enter our markets on equal terms with its British or other competitors. The benefit it received from its Government would be put into our Exchequer for the relief of the British tax-payer, and everyone would start fair. It would be a tax on foreign Government bonuses, not a tax on sugar.

This was the argument, and it was met, not with argument but with violent indignation and heated controversy. The discussion got warmer the longer it proceeded, but the warmth was all on the part of the opponents of a countervailing duty, while its advocates were quite cool and stuck to a pure economic and scientific statement of their case. They had many supporters among real political economists, and a great army of unreasoning opponents whose sole cry was that duty should be levied for revenue purposes only. The case of sugar was sufficient to show how erroneous that curious dogma really was. The Select Committee saw this at once, and the more the witnesses were cross-examined by the dogmatic party the more clear their case became. The Committee reported in favour of a countervailing duty. The minority issued a report, which was defeated by 7 to 5. Of the five who abstained, four were probably in favour of the Committee's Report. The Report was agreed to without a division.

It would require many chapters to give a full history of this interesting controversy which raged for many years. It suffices to say that in the end many opponents were converted. In 1899 the Indian Government could no longer endure the serious injury to our Indian sugar industry inflicted by the hundreds of thousands of tons of Austrian and German refined sugar which were "dumped" there when European markets were glutted

with the artificially stimulated over-production in those countries. A scale of countervailing duties was drawn up in India and submitted to Parliament in the Indian Tariff Bill of 1899. A great debate took place, and Mr. Chamberlain made an eloquent and convincing speech, in which he stated the whole case in favour of the duties with remarkable clearness and force. He challenged the House to establish once for all the principle of a duty to countervail such a foreign artificially stimulated competition as this, and the House supported him by a large majority. This was four years before his great pronouncement in 1903. Again, Sir Robert Giffen, who as one of the Government experts had fought valiantly against the sugar industries in his evidence before the Select Committee in 1879-80, made the following handsome recantation at a meeting of the Royal Statistical Society in 1902. Speaking of his evidence in 1879, he said that "he was not sure that he would have taken the same line if he had been able to look forward a quarter of a century and see what the result was to be of allowing these bounties to continue. People became wiser as time went on, and a good many of the assumptions which it was perhaps legitimate to make a quarter of a century ago had been falsified by events . . . but, having had a quarter of a century's more experience, he was satisfied that these bounties must be treated as a great infraction of free trade, and that all the countries affected by them were quite entitled to take exceptional measures to put an end to them. . . Whatever we might gain temporarily in consequence of what foreign countries gave us by these bounties, they were not to be endured, and we should join in this general movement in favour of free trade."

The Report of the Committee fell dead, and the question, so far as diplomacy was concerned, slumbered

more or less for several years. In 1880 the Government made a feeble effort to reopen negotiations, but were met at once, very properly, by the French Government, who pointed out that they could not consider the matter until the British Government were prepared to give the contracting parties security that they should not have to compete in British markets with sugar receiving similar advantages in other countries.

In 1888 an International Conference met in London and included Germany and Austria. But, though a Convention was more or less agreed to by the contracting parties, its presentation in the House of Commons for ratification was met by one or two speeches which might easily have been answered, but which apparently so frightened the Government that they promptly withdrew the Bill. Great Britain had, on this occasion, to bear the obloquy of rejecting the Convention.

The controversy raged fiercely at that time. The dogmatists had fallen back on the argument that the sale of goods below cost price was such a blessing to the consumer that it was wicked to attempt to stop it. They failed to see that if industries are injured by such competition the consumer also suffers. Production is reduced and prices rise. This is exactly what has happened with sugar. Very low prices have alternated with very high prices at regular intervals. As the late Lord Farrer pointed out, glut is followed by collapse and ruin. The short-sighted dogmatists declare, on the other hand, that they do not mind this ; they welcome ruinous prices as they do sunshine.

Another ten years elapsed, the competition among the various beetroot sugar producing countries had become more and more keen and the weaker ones began to pine for some way of escape from such an artificial state of things. Another Conference was called and

met at Brussels in 1898. The numbers had multiplied, France, Belgium, Holland, Germany, Austria, Russia, Spain, Sweden and Great Britain were now gathered together and showed some real intention to make the Conference a success. It was an interesting discussion, but all hopes of success were wrecked by Russia. It was agreed that the Russian system was a flagrant case of unfair advantages conferred by the Government on their sugar industry, with the effect of artificially stimulating production and disturbing the natural course of competition. Russia indignantly denied the imputation and the Conference broke up.

At that date Germany exported 760,000 tons of raw sugar and 426,000 tons of refined. Austria exported 377,000 tons of refined, and Hungary 40,000 tons. The average yearly exports from Russia for the period 1885-95 had been 72,000 tons, practically all refined sugar. In 1896 the Russian exports went up to 221,000 tons. An interesting foot-note to the Belgian table of (so-called) statistics says: "The figures relating to the production of sugar are approximative, the duty being based on a presumed yield." This is evidently the case, for on adding the production and imports for 1897 we get the figure of 222,185 tons, while we find the total exports amount to 236,027 tons, leaving a minus quantity for home consumption.

CHAPTER XI

BOUNTIES AND TARIFFS

THE United States Government were not going to allow their sugar industries to be ruined by the artificial system of forcing production and exportation, now a most universal throughout the European beetroot industry. They were very happy to import the sugar, but it must leave its artificial advantages at the Custom House as it passed through. The practical result of this policy was that not only tens but hundreds of thousands of tons of superfluous European beetroot sugar were imported into the States without hurting anybody, while the American revenue was swelled at the expense of Germany and Austria. The exporters paid the countervailing duty and were thankful to get rid of a good part of their overburdened stocks. The United States thus became the only market where our West Indian sugar producers could escape from this ruinous competition—it was their salvation. The Indian Government followed the example of the United States and gave the same relief to our producers in the East.

Great Britain, in the meantime, gloried in allowing the European producer to enjoy a preferential position in her markets. He was in exactly the same position as if his sugar were admitted free while all other sugar was charged with a duty. That treatment would be rank heresy if bestowed upon British producers; but the other way round it was hailed with delight as the most perfect application of the only true economic doctrine.

Our Colonial Office began to think otherwise, and the

Foreign Office was quite ready to co-operate in applying some remedy to this crying injustice, rapidly becoming a scandal. They only wanted a mandate and, fortunately, they got one. The Congress of Chambers of Commerce of the Empire met in London in 1900. The London Chamber, with some difficulty, had been induced to take up the sugar question and Sir Nevile Lubbock, Chairman of the West India Committee, was entrusted by the London Chamber with the duty of moving a resolution at the Congress, to the effect that it was time for an International Conference for the abolition of these artificial stimulants to production and exportation, and that our Government should indicate their determination to take steps, either by means of a countervailing duty or by prohibition, to put a stop to them. Sir Nevile Lubbock made a most convincing speech, and was so well backed up, not only by Sir Thomas Sutherland and by the President, Lord Avebury, but also by many distinguished Colonial delegates, that the resolution was carried by a large majority.

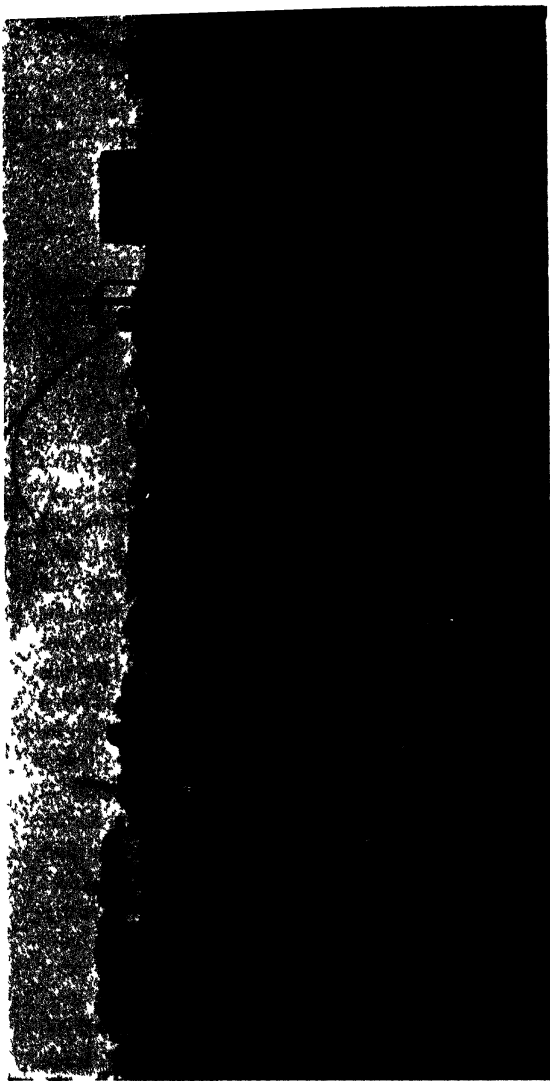
This was exactly what the Government wanted. Immediate steps were taken to call a fresh Conference, which eventually met in Brussels in the winter of 1901. This Conference was a big affair and the foreign delegates knew that the British Government—for the first time—meant business. It required a very large table to accommodate delegates representing Belgium, Austria, Hungary, Germany, France, Spain, Great Britain, Italy, Holland, Roumania and Sweden.

This Conference had to deal not only with those abuses which were rampant in 1898 but also with a new method of carrying out, on a still larger scale, the process of exterminating all unaided competitors. The manufacturers in Germany and Austria had taken a leaf out of the Russian book and developed a new way

of fighting the French. The industry in each country formed what is called a "Cartel." They were so similar, and their results so identical that it will be sufficient to describe, very briefly, the German Cartel. The consumption duty, that is, the duty actually paid by the consumer, was 10s. per cwt. ; but the import duty, that is, the duty which anyone outside would have to pay in order to enter into the competition, was 20s. per cwt.—just double. The surtax on imports was, therefore, 10s. per cwt. and, within the limit of that large amount, the home producer could raise his price to the consumer without fear of outside competition. But to effect this it was necessary that the whole industry should combine. They did so, and bound themselves down under severe penalties to adhere to the arrangement. The refiners were to raise the price to the consumer and to pay the raw sugar producers a fixed share of the resulting profit. The practical outcome was that the raw sugar producer received 3s. 6d. per cwt. more than the outside value of his sugar, while the refiner enjoyed the balance of the profit—4s. 6d. per cwt. These were, indeed, glorious profits. The great glut of sugar was rapidly increased, but the profit in the home market was so large that they could afford to sell their surplus for what it would fetch and yet make an abnormal profit on their total out-turn. The value of sugar in the world's markets fell 3s. per cwt. below the cost of production, but the German producers were delighted, declaring that the right policy was to keep prices down so as to crush all outside competition. They very nearly succeeded. This was regarded with dismay not only by the ordinary unaided producer but also by the rest of the beetroot industry itself, which had long enjoyed and still retained the smaller benefits so generously bestowed upon them by their paternal Governments.

This was the state of tension in which the Conference met at Brussels, and this was the one subject for discussion—to abolish the Cartels. It was a long and tedious process, but by the end of February, 1902, the work was completed and all that remained was to wait anxiously for the ratification of the Convention which was provisionally signed on the 5th March, 1902, and came into force on the 1st September, 1903.

The usual margin between prices of raw and refined sugar in Germany was 3s. 6d. per cwt., but when the Cartel was in operation it rose to 10s. 6d., and when the Cartel was abolished by the Convention it fell again to the normal figure. On 15th January, 1902, a calculation of the profit arising from the Cartel, based on the prices of the day, gave the figure of 7·90 marks per fifty kilogrammes, that is, nearly 8s. per cwt. of sugar consumed. This, calculated on a consumption of 703,507 tons, showed a profit of £5,558,495 for the industry, with which they could make contributions to those who lost money on exports. The German Cartel profit was sufficient to furnish a bonus of about 5s. 5d. per cwt. on the refined exported, or 4s. 10d. per cwt. on the raw sugar exported. The Austrian Cartel profit, calculated in the same way, was found to amount to more than 9s. per cwt. of sugar consumed, showing an annual Cartel fund of £2,957,868, sufficient to furnish a bonus of 4s. 8d. per cwt. on the refined sugar exported, or 4s. 2d. per cwt. on the raw sugar exported. In the year ending July 31st, 1902, Austria-Hungary produced 1,171,056 tons, consumed 349,117 tons, and exported 739,186 tons. In the same year Germany produced 2,302,246 tons, consumed 743,520 tons, and exported 1,144,317 tons. Together, these two countries were able to furnish the outside world with nearly 2,000,000 tons of sugar. They were selling it at 3s. per cwt. below



Queensland Government

ISIS CENTRAL SUGAR MILL

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the cost of production and hoped soon to become masters of the situation.

The Convention put a stop to the Cartels by fixing the surtax at a maximum of 2s. 6d. per cwt. This was more than enough to keep out competition, and the British delegates feared that a Cartel might be formed to exploit even this reduced surtax ; but the situation was critical, and it was better to accept the compromise. Subsequent experience has shown that half that surtax suffices to keep out competition. The large surtaxes, therefore, can have had no other object than to enable producers to raise prices in the home market. This is why excessive surtaxes must always be regarded as a form of State aid calculated to stimulate production and exportation with the result of disturbing the natural course of the world's industry and trade. There is nothing to prevent the same system being applied to iron, steel, cotton or woollen goods or any other article of commerce.

The details of the Convention were summarized by the late author in the *Economic Journal* (Journal of the Royal Economic Society) for March, 1904, from which he makes the following brief extracts—

The first Article of the Convention declares that the contracting parties undertake to suppress direct and indirect bounties on the production or exportation of sugar, and proceeds to define, as follows, some instances of the way in which such advantages may result from State legislation.

- (a) Direct bounties granted to export.
- (b) Direct bounties granted to production.
- (c) Total or partial exemption from taxation granted for a part of the manufactured product.
- (d) Advantages derived from excess of yield.

- (e) Advantages derived from the exaggeration of the drawback.
- (f) Advantages derived from any surtax in excess of the rate fixed by Article III.

Definition (f), inserted at the instance of the British delegates, was absolutely essential in order to meet the case of the Cartel bounties. They proposed to define Cartel bounties as "advantages derived from any surtax," but in view of the critical state of the negotiations accepted the limitation. The first Article is, therefore, so far inconsistent that, though it declares the abolition of all bounties, it permits any Cartel bounty which may be obtained from the reduced surtax fixed by Article III. The figure of this surtax was, of course, a great bone of contention, but was finally fixed at six francs per 100 kilogrammes, that is, 2s. 6d. per cwt.

The direct bounties in Germany, France, Austria and Holland came under definitions (a) and (b). The bounties defined under (c), (d) and (e) belong to one family and are practically interdependent. Levying the duty on an estimated yield is probably followed by the obtaining of a yield in excess of the estimate, and consequently by "a total or partial exemption from taxation for a part of the manufactured product." But this would not necessarily create a bounty unless the full amount of duty were returned in drawback on export. In that case the manufacturer can obtain the full duty from the home consumer; but if it were not so the exemption from taxation would merely operate as a reduction of duty to the consumer. Where the full drawback is returned on export, though the full duty has not been paid by the manufacturer, the drawback becomes practically an exaggerated one and the bounty

is really the result of a combination of the cases defined in (c), (d) and (e).

The second Article abolishes such bounties as are here defined by prescribing excise supervision of factories and refineries, so that no duty shall be charged on the estimated yield, and therefore no drawback paid on exported sugar. The sugar will be manufactured and refined "in bond," that is, without having paid any duty; drawbacks will thus be abolished, and the sugar for home consumption will pay the duty when delivered for that destination.

The third Article fixes the maximum surtax at six francs per 100 kilogrammes.

The fourth Article is the penal clause, the object of which is to give the contracting States security that they shall not in future have to compete with bounty-fed sugar. It declares that a duty not less than the amount of the bounty shall be imposed in the markets of the contracting States on sugar from all countries that grant bounties. In the case of bounties arising from a surtax higher than that fixed by Article III, the countervailing duty shall be calculated by deducting from the surtax the figure so fixed and taking half the difference as representing the bounty.

These then are the salient points of the Convention. the decision to abolish all bounties; the establishing of manufacturing and refining "in bond"; the limitation of the surtax; and the security to the contracting Powers that bounty-fed sugar will no longer be tolerated in their respective territories.

There is one minor point in the Convention which calls for a word of comment. The fourth Article lays down the rules for countervailing a bounty by means of an equivalent duty, but it adds as an alternative that the high contracting parties reserve to themselves the power

to prohibit the importation of bounty-fed sugar. This appears to have arisen from some curious superstition on the part of the British Government that a duty might be regarded as contrary to the principles of free trade, but that prohibition could not fall under that stigma.

If this was the idea it shows a curious want of grasp of the subject. A bounty destroys free trade in the country which receives the bounty-fed commodity, because the producer of that commodity is at once placed in a position of favour as compared with his competitors who receive no bounty. The foreign producer is practically protected by his bounty in British markets if his sugar is allowed to be imported in open competition with sugar which receives no bounty. The effect is exactly as if the bounty-fed sugar were admitted free and the other, receiving no bounty, were struck with a duty. To eliminate this inequality is the sole object of the countervailing duty. It is, in fact, a duty on bounties, not on sugar. It accepts the bounty for the benefit of the whole nation of taxpayers by putting it into the Treasury, and leaves the sugar to compete with all other sugar on equal terms. Therefore, under a system of countervailing duties we do not lose the benefit of the bounty, we do no injustice to the bounty-fed producer, and we save the consumer from the danger to his interests arising from the effect of bounties in discouraging and eventually destroying his natural sources of supply. None of these arguments can be used in favour of prohibition.

The Convention expired in 1908 and had to be renewed. The British Government, generally so simple-minded and easily over-reached, did a crafty thing. Five years previously they had yielded to the reasonable demand of the foreign governments who, for thirty years, had

persistently urged that they could not be bound by treaty, to abolish their bounties until Great Britain undertook that they should no longer have to compete on British markets with bounty-fed sugar. Having at last secured the abolition of the bounties, the British Government, at the earliest opportunity, turned round and declared that they were about to readmit bounty-fed sugar to their markets. The foreign governments were in a position of great difficulty. They had no desire to revert to the ruinous system of former days and they had to give in.

Russian sugar, with its bounty, was to come in without let or hindrance. There was a great flourish of trumpets. The system of restricted "importation" was to be abolished. This was really quite immaterial. The world produced 14,000,000 tons of sugar, and we consumed one million and a half. There were at least 12,000,000 tons (the rest went to the United States) from which we were free to make our selection. There was, therefore, no restriction. Russia, it appears, after sending her usual exports to Finland and Persia, had an average surplus of about 40,000 tons, some of which might come here. What was this drop in the ocean of 14,000,000 tons? As it happened, Russia had then no surplus. So much for restriction of imports.

There were loud cries, when the Convention was coming into force in 1903, that the price of sugar would be raised enormously. Great political economists, with a turn for mathematics, sat down and calculated the exact figure. Our consumption, they said, was 1,600,000 tons, and the bounties were £5 per ton. Multiply the consumption by five and you get £8,000,000. Realise the loss to the British consumer! They were not aware that price is governed by supply and demand and by nothing else. But, nevertheless, the figure was

freely quoted even by statesmen of the highest rank and was eagerly swallowed as an indisputable fact. They must have been quite surprised to find that supply and demand went on governing market prices just the same as usual, and, as there happened to be too much sugar, prices went down instead of up. Then a most fortunate accident happened for the alarmists. The European beetroot crop of 1904-5 suffered from a severe drought and produced 1,200,000 tons less sugar than the estimate. Prices naturally rose and the alarmists cried, "We told you so." The rise which took place was, in fact, a clear proof of the danger to consumers in having to depend on one crop, confined to a small portion of Europe, for their supply of sugar. And this dependence on one crop was the direct effect of the bounties. So it was the bounties that were really the cause of the scarcity and the high prices. Europe, of course, sowed a large acreage in 1905, on the strength of the good prices, and had a fine season and a bumper crop. In August, 1905, we were back again at the old price, a price even below the cost of production. The beetroot sugar industry maintains its production, and even continues to increase, but not to such an abnormal extent as during the bounty period. The industry has been firmly established and will continue to flourish, but it can no longer sell for export below cost price. Cane sugar now has a fair chance. The figures in Appendix III show how the fight between the producers of beet and cane sugar is going. In 1907-8 both the cane and the beet crop were about 7,000,000 tons, and thus each provided half the world's production. In 1912-13 the cane crop was showing the results of a gradual increase, which has continued ever since, particularly during that period when Europe was suffering from the War or its after effects. To a great extent the

variation in figures during recent years is due to the very low value to which raw sugar has fallen. In 1927 raw cane sugar of standard 96° polarization cost as much as 16s. per cwt. in bond. In 1928 the value fell from 13s. to 9s., and the following year it suffered a further reduction to 8s. At the beginning of 1930 96° cane was valued at 8s. 6d., but by the end of January it had fallen to 7s. 6d., and remained at this value until May, when a further decline set in, which continued until it reached 6s. in July. During the following fourteen months the price remained at about the same level, but in September, 1931, England abandoned the Gold Standard and the price in this country increased about 1s. to 7s., although the world value at the commencement of 1932 remains at about 6s. When it is realized that the 1913 pre-war value was about 9s. 6d., it can be readily understood that the present price of 6s. is not a profitable one to the growers, and their financial position was so unsatisfactory that, in 1930, Mr. Chadbourne, a New York banker and authority on sugar questions, suggested that countries which exported sugar should limit their production to mutually agreed quantities and thus avoid over-production, which was the cause of low prices. Many difficulties had to be surmounted, but, on 9th May, 1931, an agreement was signed in Brussels by the most important sugar-exporting countries (excluding Russia) under which each country agreed not to export more than a certain quantity during each of the ensuing five years. Provision was made to deal with existing stocks and with possible fluctuations of prices. The plan was well conceived and most ably carried through and promises to work satisfactorily, although it has had to contend with the general depression of all industries, which works against it, and further curtailments of exports are being considered.

CHAPTER XII

THE SUGAR MARKET

COMING now to the subject of the sugar market, the West India merchants and their brokers, together with merchants and brokers who dealt in sugar from other quarters of the world, were the sellers. The buyers were the refiners and the wholesale grocers or dealers in raw grocery sugars. But these wholesale grocers had also another market to attend, and a very important one—the refined market. All the refined sugar consumed in the country practically came from British refiners, so that, in the case of London, a buyer from every wholesale grocer or dealer had to make a tour of the East End early every morning to call on some twenty refiners and buy their goods. In Mincing Lane work began at 9 a.m., estimating values ; then a visit to every private saleroom where West Indian sugar was on show ; then the public sales at 1 o'clock, which often lasted for an hour or more ; so that the industrious buyer often did not get his work done till 3 p.m.

The Mincing Lane sugar market of to-day is a very different thing. The public sales are a mere nothing, West India brokers have nearly disappeared, the advent of the merchant at noon is a thing of the past, and you can buy a thousand tons of sugar in five minutes. This transformation is all the result of the beetroot sugar industry. Beetroot came into Mincing Lane at first in pill boxes, carried furtively by the seller in his waistcoat pocket and shown in a deprecating way as being a very impertinent intrusion. Only one or two refiners would try the experiment, but they did not regret it.

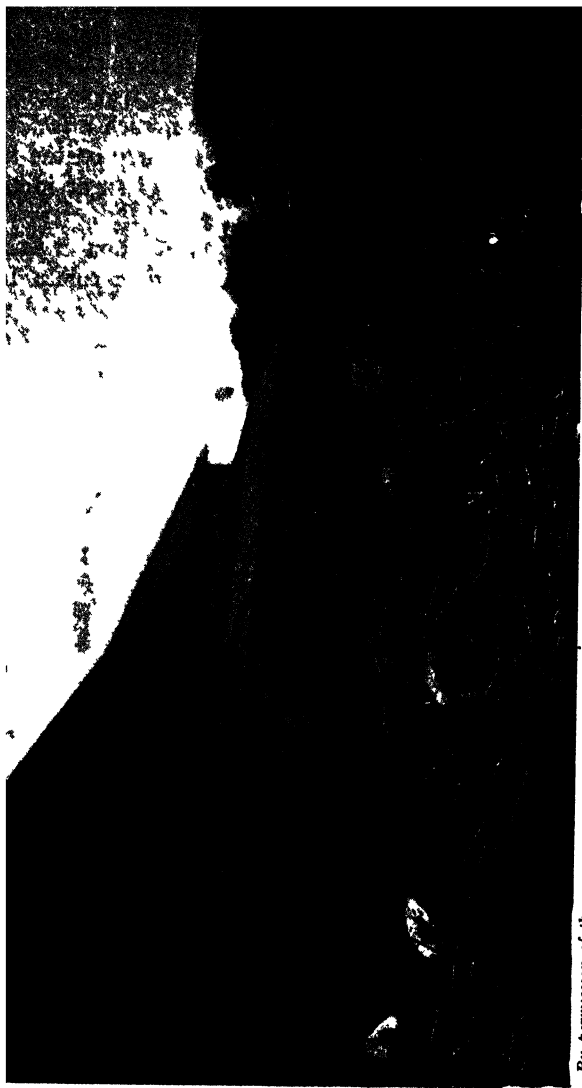
In Greenock one wide-awake sugar refiner informed his broker that he did not want to buy hundreds of tons, he wanted to buy thousands. Here was a grand opportunity for some intelligent and enterprising foreigner to develop a new business. He came exactly at the right moment, and at the end of his career he was one of the greatest sugar-brokers of the world. He not only supplied the refiners with their raw material but, eventually, had every kind of foreign refined ready for the wholesale grocer. One of the oldest established houses among the English sugar-brokers followed his example, opened branches in Paris and Magdeburg, and ran a very good race with him.

Then came a great help. Those refiners who used beetroot sugar on a large scale soon felt the want of some organization for getting rid of the constant worry of complaints of quality and weight in the deliveries of the beetroot sugar they were importing. The result was the foundation of the London Beetroot Sugar Association. This organized body of buyers and sellers has worked admirably. A form of contract was established which became, eventually, a very complete and effectual document. Every dispute is now settled by arbitration, carried out by the Council of the Association in a simple but efficient manner. The sugar is bought and sold on the basis of analysis. Samples are most carefully taken under the supervision of officers of the Association. A portion of the sample is placed in three sealed bottles, of which one goes to the seller, one to the buyer, and the third to the laboratory of the Association. If there is a serious discrepancy between buyer's and seller's analysis the third sample is analysed by the chemist of the Association, and the average of the two nearest analyses is taken as the basis of the invoice. Here is at once a system which makes the buying and

selling of sugar mere child's play. The large brokers with their branches abroad can let you have any quantity of sugar you desire.

The British sugar refiners now refine 1,852,264 tons of raw sugar. About half this indicates the quantity of refined sugar which we formerly imported. In addition to this we have to add the 267,895 tons of white sugar which was turned out by the Home Grown Beet Factories in 1930, the balance of their output being raw sugar sent to the Refineries. The foreign refiner now supplies our consumers with only 59,000 tons of refined sugar every year, so that here we have 2,000,000 tons accounted for without any of the old trouble of valuing and attending public sales, or visiting countless private show-rooms, at the expense of many hours of valuable time. There only remains to be dealt with in the old-fashioned way about 200,000 tons of grocery or miscellaneous cane sugar, including, of course, our fine colonial produce, such as the splendid yellow crystallized sugars from Demerara and the West India Islands. This is the change that has come over the Mincing Lane sugar market since 1860.

But the change has not created a wilderness, as might be supposed. On the contrary, the members of the sugar market are there in numbers. This is the speculative market, a new invention not so very long ago, but now, in the eyes of the members, a very old affair. There is a "Call" in the morning, another in the afternoon, where prices fluctuate, not as much as in the old days of real buying of solid sugar, but by pennies. When the market is really active there may even be a violent rise of sixpence. All this may seem very childish but it has its practical side. A big *bona fide* sugar-broker sells thousands of tons of sugar to a refiner, and he can at once cover his sale in the market by buying a thousand tons of imaginary sugar for delivery at once



By permission of the

UNLOADING SUGAR CANES AT THE FACTORY

Queensland Government

or at some future time. He is perfectly safe, thanks to the strict organization, and if he elects to take delivery he will get the sugar. He can thus hedge both his purchases and his sales, and without such a facility it would be impossible with safety to carry on the large operations necessary for the supply of sugar in these days.

There was some pleasure and satisfaction in the old days in exercising the knowledge that comes from practical experience and selecting with care and skill the best article at the lowest possible price. That part of expert knowledge in the sugar industry has gone.

The beetroot industry is beginning to get anxious as to its future prospects. Professor Dr. E. O. von Lippmann, at the head of the German industry both as expert and leader, a few years ago expressed his alarm with no uncertain sound. He pointed to the rapid recovery of cane sugar since the Brussels Convention, to its monster factories, to its large yields of sugar to the acre, and, worst of all, to its low cost of production. He went on to remind his audience how he had urged, formerly, that the low prices were, from their point of view, in conformity with the interests of the European industry. But, he continued, better prices contain a danger, because they are calculated to provoke a new and notable extension of the cultivation of the sugar cane. He also lamented that German raw sugar had deteriorated in quality and that German refined sugar had lost its reputation. They must organize, he said, and if the industry will not take the necessary measures it is not for want of warning. This was in a very minor key. In the days when beetroot was master he had urged that low prices must be maintained in order to crush competition. That he very nearly succeeded we all know, and the fact was admitted even by such a powerful

authority as *The Times*. In the Financial Supplement to *The Times* of December 17th, 1909, there was a leading article on "The Rise in Sugar," in which the late author, after some interesting comments on the position, continued as follows—

"But what must strike the observing man who inquires into the facts of the situation is the probability that but for the Brussels Convention the rise in sugar in this country, instead of being 2s., might have been 20s. per cwt. For if the Convention had not put an end to the bounty system on the Continent the cane sugar industry by this time would have been practically dead, and we should have been entirely dependent on the supplies of the Continental beet growers. And it is the comparative failure of the beet harvest this year that is the real and only cause of the rise in sugar. . . . To all intents and purposes, then, we should be faced with a shortage of about half-a-million tons in the European needs for sugar were it not for the most welcome increase in the production of cane sugar, and that increase could not and would not have occurred under the bounty system."

The authors of the Brussels Convention were pleased to receive this unexpected and most weighty testimonial. For thirty years they were branded as economic infidels and heretics, but it appeared, on this very high authority, that their political economy was sound, that they have done a good deed and saved a valuable industry from destruction. A good deal of injury might have been avoided—injury to consumer as well as producer—if their advice had been listened to at the outset of the disease.

The same may be said regarding the alterations in the scaling of the Sugar Duty made by Mr. Churchill in

his 1928 Budget. These alterations had the effect of excluding foreign white sugar from this country, the refining of raw sugar being carried out in this country by British labour and British capital. Furthermore, with the aid of the reduction in duty called Preference granted on all sugar produced within the Empire, the Dominion and Colonial producers now find a ready market here for their raw sugar. Nor has the consumer suffered thereby, for the competition between all the producers of white sugar, namely, the refineries and the home grown beet factories, is so keen that prices are lower than ever.

APPENDIX

I.—SUGAR CROPS OF THE WORLD (*Willet & Gray, New York, Nov., 1931*)

<i>Cane Sugar</i>	1931-32 <i>Tons</i>	1925-26 <i>Tons</i>	1917-18 <i>Tons</i>	1913-14 <i>Tons</i>
United States—				
Louisiana	145,000	124,447	217,499	261,337
Texas	—	—	2,009	7,000
Porto Rico	835,000	544,484	405,174	325,000
Hawaiian Islands	900,000	705,350	515,035	550,925
West Indies—				
Virgin Islands	20,000	5,664	5,400	—
St. Croix	—	—	—	5,800
Cuba	3,000,000	4,884,658	3,446,083	2,597,732
British West Indies—				
Trinidad	90,000	73,651	45,256	47,251
Barbados	62,000	47,535	65,230	33,267
Jamaica	65,000	57,675	34,300	15,583
Antigua	14,000	12,800	9,409	—
St. Kitts	15,000	16,380	8,846	—
Other British Islands	5,500	7,500	16,745	24,000
French West Indies—				
Martinique	39,000	48,121	20,881	38,730
Guadeloupe	28,000	32,998	28,000	39,920
San Domingo	365,000	354,720	127,332	105,778
Haiti	18,000	11,249	—	—
Mexico	200,000	190,282	40,000	130,000
Central America—				
Guatemala	32,000	25,151	—	—
Other Central America	72,000	62,500	25,000	22,000
South America—				
Demerara	110,000	107,580	114,007	101,725
Surinam	14,000	10,000	9,739	14,000
Venezuela	18,000	19,000	15,000	3,000
Ecuador	20,000	16,976	8,000	—
Peru	514,000	265,000	265,000	176,671
Argentina	365,000	395,733	87,699	280,319
Brazil	975,000	650,000	148,958	203,394
Total in America	7,903,500	8,669,364	5,660,592	4,983,432
Asia—				
British India	3,100,000	2,923,000	3,311,000	2,291,500
Java	2,500,000	2,278,900	1,778,345	1,345,230
Formosa and Japan	920,000	498,460	397,618	190,000
Philippine Islands	800,000	436,000	216,260	225,000
Total in Asia	7,320,000	6,136,360	5,703,223	4,051,730
Australia	535,000	522,344	325,900	255,000
Fiji Islands	80,000	90,000	70,800	100,000
Total in Australia and Polynesia	615,000	612,344	396,700	355,000

I.—(continued)—

<i>Cane Sugar</i>	1931-32 <i>Tons</i>	1925-26 <i>Tons</i>	1917-18 <i>Tons</i>	1913-14 <i>Tons</i>
Africa				
Egypt	95,000	95,000	79,450	67,000
Mauritius	175,000	241,220	225,466	241,990
Réunion	35,000	59,015	50,000	37,000
Natal	300,000	214,152	106,250	85,714
Mozambique	85,000	70,000	50,000	34,000
Total in Africa	690,000	679,387	511,166	465,704
Europe—Spain	12,500	9,000	7,039	13,231
Total Cane Crops	16,541,000	16,106,455	12,278,720	9,869,097
Beet Sugar				
Europe—Beet Sugar Crop	8,335,000	7,423,073	4,247,406	8,243,165
United States— Beet Sugar Crop	1,010,719	804,439	682,867	655,298
Canada—Beet Sugar Crop	38,500	32,475	11,250	10,007
Total Beet Crops	9,384,219	8,259,987	4,941,523	8,908,470
Grand Total—(Cane and Beet)	25,925,219	24,366,442	17,220,243	18,777,567

II.—CROPS OF BEETROOT SUGAR ON THE CONTINENT OF EUROPE

	1931-32 <i>Tons</i>	1925-26 <i>Tons</i>	1917-18 <i>Tons</i>	1913-14 <i>Tons</i>
Germany	1,650,000	1,595,545	1,541,061	2,738,000
Czecho-Slovakia	830,000	1,485,031	688,250	1,710,000
Austria	165,000	78,145	{	{
Hungary	145,000	172,560		
France	910,000	757,987	200,265	800,000
Belgium	240,000	332,170	131,000	230,000
Holland	180,000	306,083	199,295	230,000
Russia (Ukraine, etc)	2,150,000	1,041,903	1,028,580	1,750,000
Poland	560,000	575,673	{	{
Sweden	142,000	204,500		
Denmark	125,000	179,998	125,000	134,933
Italy	360,000	160,296	115,000	143,246
Spain	347,000	243,939	100,000	327,800
Switzerland	6,000	6,395	134,955	157,469
Bulgaria	28,000	38,000	4,000	5,000
Roumania	65,000	115,907	—	7,800
England	291,000	51,140	—	32,000
Other Countries	141,000	94,465	—	3,744
Total in Europe	8,335,000	7,440,367	4,247,406	8,269,992

III.—PROGRESS IN CANE AND BEET PRODUCTION SINCE 1903, the date of the Convention

Year	Beet			
	Cane	Europe	United States and Canada	Total World's Production
1903-4	4,234,000	5,881,000	208,000	10,323,000
1904-5	4,594,000	4,708,000	209,000	9,511,000
1905-6 ¹	6,731,000	6,932,000	283,000	13,946,000
1906-7	7,329,000	6,710,000	433,000	14,472,000
1907-8	6,922,000	6,562,000	440,000	13,924,000
1908-9	7,633,000	6,543,000	384,000	14,560,000
1909-10	8,327,000	6,137,000	450,000	14,914,000
1910-11	8,390,000	8,095,000	455,000	16,940,000
1911-12	9,067,000	6,279,000	541,000	15,887,000
1912-13	9,232,000	8,341,000	635,000	18,208,000
1913-14	9,821,000	8,179,000	667,000	18,667,000
1914-15	10,288,000	7,583,000	660,000	18,531,000
1915-16	10,667,000	5,077,000	797,000	16,541,000
1916-17	11,169,000	4,764,000	747,000	16,680,000
1917-18	12,278,000	4,247,000	694,000	17,219,000
1918-19	11,991,000	3,250,000	697,000	15,938,000
1919-20	11,905,000	2,594,000	669,000	15,168,000
1920-21	12,071,000	3,672,000	1,004,000	16,747,000
1921-22	12,768,000	3,973,000	930,000	17,671,000
1922-23	12,917,000	4,575,000	628,000	18,120,000
1923-24	14,250,000	5,058,000	803,000	20,111,000
1924-25	15,532,000	7,080,000	1,010,000	23,622,000
1925-26	16,106,000	7,423,000	837,000	24,366,000
1926-27	16,029,000	6,872,000	832,000	23,733,000
1927-28	16,293,000	8,032,000	992,000	25,317,000
1928-29	17,921,000	8,470,000	967,000	27,358,000
1929-30	18,154,000	8,248,000	929,000	27,331,000
1930-31	16,965,000	10,578,000	1,116,000	28,659,000
1931-32	16,541,000	8,335,000	1,049,000	25,925,000

¹ The jump in the figure for cane sugar production, from 4,594,000 tons in 1904-5 to 6,731,000 tons in 1905-6, is misleading. It is caused by the sudden inclusion, by the statisticians, of a more or less imaginary figure as representing what was for the first time officially announced to be the estimate of the native production of sugar in British India. (See p. 89.)

IV.—PROGRESS OF THE EUROPEAN BEET SUGAR
PRODUCING COUNTRIES during the period of the
Convention, 1903-14

(Journal des Fabricants de Sucre)

	1903-4	1913-14	Difference
	TONS	TONS	PER CENT.
Germany	1,929,410	2,725,000	+ 41·2
Austria	1,158,800	1,692,000	+ 46
France	794,430	786,000	- 1·06
Russia	1,160,660	1,731,000	+ 49·1
Belgium	202,850	230,300	+ 13·5
Holland	123,500	228,600	+ 85·1
Sweden	107,240	136,500	+ 27·2
Denmark	45,900	146,000	+ 218
Italy	135,000	327,800	+ 142
Spain (beet)	70,800	160,000	+ 125
	5,728,590	8,163,200	

The progress of Germany, Austria, Belgium, Holland, and Sweden was a natural increase to keep pace with increased consumption. The increase in Russia was artificial, because there was a bounty. Italy and Spain had protected markets and no surplus. The rapid growth of the Danish and Dutch industries is very creditable. There are several reasons for the stationary condition of France, of which high cost of production is one.

V.—CROPS OF CANE AND BEETROOT
PER ACRE AND YIELD OF SUGAR

Country	Tons per Acre	Tons of Raw Sugar per Acre
	Beet	
England . .	8.76	1.25 ¹
Germany . .	10.42	1.62
Austria . .	11.29	1.69
France . .	11.16	1.55
Russia . .	6.78	1.03
Belgium . .	12.01	1.80
Holland . .	11.66	1.82
Denmark . .	12.78	1.97
Sweden . .	12.30	1.93
	Cane	
Cuba . .	19.50	2.15
Java . .	43.26	5.14
Hawaii . .	47.32	5.75
Australia . .	17.75	2.45
Philippines . .	11.61	0.88
Porto Rico . .	16.04	1.68
Mauritius . .	13.59	1.32

Chiefly white sugar.

VI.—DEVELOPMENT OF THE UNITED STATES BEET-SUGAR INDUSTRY SINCE 1900

(Truman G. Palmer)

TONS OF 2,000 LB.

Years	Acres harvested	Raw Sugar	Roots per Acre	Sugar per Acre	Sugar Extraction per 100 of Roots	Tons of of Sugar per Factory
		Tons	Tons	Pounds		
1900-1	132,000	95,646	6.15	1,449	11.78%	2,813
1901-2	175,083	205,111	9.63	2,343	12.17	5,697
1902-3	216,400	242,672	8.76	2,243	12.80	5,918
1903-4	242,576	267,337	8.56	2,204	12.87	5,455
1904-5	197,784	269,014	10.47	2,720	12.99	5,604
1905-6	307,364	347,690	8.67	2,262	13.04	6,686
1906-7	376,074	537,346	11.26	2,857	12.68	8,529
1907-8	370,984	515,142	10.16	2,777	13.67	8,176
1908-9	364,913	473,204	9.36	2,594	13.86	7,632
1909-10	420,262	569,410	9.71	2,710	13.95	8,760
1910-11	398,029	566,857	10.17	2,848	14.01	9,292
1911-12	473,877	666,111	10.68	2,811	13.16	10,092
1912-13	555,300	769,507	9.41	2,772	14.73	10,541
1913-14	580,006	814,890	9.76	2,810	14.40	11,477
1914-15	483,400	802,282	11.6	3,319	15.17	13,371
1915-16	611,301	971,356	10.7	3,180	15.79	14,498
1916-17	665,308	911,841	9.36	2,741	15.40	12,322
1917-18	664,797	860,625	8.46	2,580	13.60	9,459
1919-20	692,455	816,750	9.27	2,340	13.34	9,183
1920-21	871,676	1,225,125	9.79	2,800	13.63	12,687
1921-22	814,988	1,147,500	9.55	2,820	13.76	12,479
1922-23	530,247	759,370	9.77	2,860	13.61	9,346
1923-24	657,000	990,000	10.66	3,000	13.41	11,132

VII.—OUR HOME CONSUMPTION

For the last complete year before the war, the first complete year during the War, 1926, and 1930

	1913	1915	1926	1930
	TONS	TONS	TONS	TONS
Refined (Imported)	899,327	572,618	696,463	54,928
Refined (in Bond) in the United Kingdom	715,661	784,316	788,022	1,182
Raw	116,942	293,276	143,978	1,935,788
Total	1,731,930	1,650,210	1,628,463	1,991,898
Less Exports of British Refined	23,271	4,972	77,839	3,902
Total consumption of Sugar	1,708,659	1,645,238	1,550,624	1,987,996
Molasses	15,8162	145,703	6,138	7,718
Molasses manufactured in United Kingdom	85,584	70,125	65,432	6
Total consumption of Molasses	243,746	215,828	71,570	7,724

VIII.—THE IMPORTS OF SUGAR INTO THE UNITED KINGDOM FOR THE LAST COMPLETE YEAR BEFORE THE WAR, THE LAST YEAR DURING THE WAR, 1926, AND 1930—a very interesting comparison

Unrefined Sugars	1930 Tons	1926 Tons	1918 Tons	1913 Tons
Germany	57,828	13,694	—	471,689
Netherlands	—	—	7,691	11,377
Poland	46,097	13,574	—	—
Belgium	—	—	—	2,526
France	—	—	—	18
Austria-Hungary	—	—	—	161,038
Czechoslovakia	607	342	—	—
Java	6	50	186,193	99
Cuba	740,772	273,488	823,901	223,980
Dutch Guiana	—	—	3,012	4,501
Haiti and San Domingo	237,439	106,970	—	9,409
Mexico	—	—	—	4,132
Peru	118,754	122,804	41,696	27,520
Brazil	72,642	6,867	8,325	5,141
Mauritius	136,072	204,081	94,416	20,178
British India	—	—	42	3,850
British West Indies }	80,498	98,904	115,914	47,711
British Guiana }	—	—	—	—
British Honduras }	—	—	—	—
Philippine Islands	—	—	—	—
Other Countries	102,566	228,209	2,909	53,312
TOTAL RAW SUGARS	1,852,264	1,068,983	1,284,099	1,046,481
<i>Refined Sugars—</i>				
Russia	—	—	—	2,940
Germany	805	30,370	—	466,749
Holland	15,113	236,687	6,003	178,789
Belgium	1,114	15,299	—	49,920
France	—	—	12	26,576
Austria-Hungary	—	—	—	198,431
Poland	726	11,720	—	—
Mauritius	—	—	4,171	—
Java	—	—	493	—
United States	9,218	12,057	5,276	—
Argentina	—	—	83	—
Canada	5	65,948	—	—
Czechoslovakia	31,905	316,798	—	—
Other Countries	135	10,602	5,514	1,395
TOTAL REFINED SUGARS	59,020	699,480	21,551	924,800
Molasses	284,511	152,808	65,597	164,908
TOTAL IMPORTS	2,196,225	1,921,271	1,371,247	2,136,189

IX.—EUROPEAN *per capita* SUGAR CONSUMPTION

Country	Population	1912-13	1921-22	1925-26
Australia . . .	5,435,000	109·37	100·0	113·9
United States . .	106,000,000	85·40	99·0	118·8
Denmark . . .	3,300,000	98·16	99·0	118·8
Switzerland . . .	4,000,000	77·24	75·0	83·3
Sweden . . .	6,000,000	57·09	74·0	76·3
United Kingdom . .	47,500,000	98·16	70·0	91·5
Holland . . .	7,213,000	40·90	68·0	67·3
Germany . . .	63,000,000	49·26	54·0	49·7
Belgium . . .	7,500,000	39·20	44·0	54·3
France . . .	40,000,000	43·47	35·0	53·2
Austria . . .	6,600,000	} 28·14	24·0	65·5
Hungary . . .	8,000,000		17·0	24·2
Spain . . .	21,750,000	15·62	17·0	23·7
Roumania . . .	18,000,000	8·89	14·0	14·5
Italy . . .	42,000,000	11·05	12·0	19·3
Bulgaria . . .	5,000,000	7·83	12·0	12·5
Russia . . .	108,000,000	24·31	5·0	16·0

X.—RESULTS OF A GERMAN SUGAR FACTORY, SEASON 1908-9

This is given not as indicating the average results of beet sugar production, but as a remarkable instance of success in a good season.

Roots, 24,600 kilos. per hectare, equal to about 10 tons to the acre, against $10\frac{1}{2}$ tons the year before.

Roots worked, 135,959 tons ; average polarization, 17·10. Price of roots, 21s. per ton.

Working Expenses per ton of Roots

	Shillings.
Coal	1·38
Materials	·53
Lime	·56
General Expenses .	·264
Repairs	·58
Wages	2·196
Insurance of Workmen	·176
Contributions . .	·41
Insurance	·092
	<hr/>
Total	6·188
Roots	21·136
	<hr/>
	27·32
Depreciation . . .	1·07
	<hr/>
Total cost per ton of roots	28·39 Shillings.

Six tons of roots produced one ton of sugar. The cost per ton of roots being 28·39 shillings, the cost per ton of sugar is 170·34 shillings, or £8 10s., or 8s. 6d. per cwt.

Sugar Produced

	Tons
First products (average analysis, 90·25) .	20,818
Second products (average analysis, 81·52)	1,805
Molasses	1,806

Yield per cent. of Roots

First products . . .	15.31
Second products . . .	1.33
	<hr/>
Total . . .	16.64 per cent.
	<hr/>
Molasses . . .	1.33 „ „

Average Prices

First products, 10s. per cwt., basis 88, f.o.b.
 Second products, 8s. 6d. per cwt., basis 75, f.o.b.

	s.	d.	
Receipts for sugar . . .	10	6	per cwt.
Expenses . . .	8	6	„
	<hr/>		
Profit . . .	2	0	„

Profits, £45,076, equal to 29 per cent. on capital.

Dividend of 22 per cent. paid, after payments to reserves and bonuses.

Of the rest, £8,669 was paid to the growers on account of the good year and the short weight but good quality of the roots.

Dried pulp, 2,603 tons, consumed 1,482 tons of coal, and fetched £8,335 net, after deducting expenses of drying.

Other factories paid 30 to 35 per cent. dividend. The high yield of 16 to 17 per cent. of sugar from the roots made the season a very profitable one to the factories.

XI.—THE PRICE OF SUGAR DURING THE CONVENTION PERIOD, 1903–1914

The average cost of production of European raw beetroot sugar, basis 88 per cent., f.o.b. Hamburg, was between 9s. and 10s. per cwt.

The price from September, 1903, to July, 1904, was below cost of production. A failure of the crop in 1904 caused a deficiency of 1,200,000 tons in the supply of sugar, and prices consequently rose. The 1905 crop was a heavy one, and prices fell from 16s. in January, 1905, to 11s. in July and 8s. 9d. in August—once more below the cost of production. In 1906 prices were below 9s., and for many months far below cost of production. During 1907 prices ranged between 8s. and 10s. In 1908 they ranged between 9s. 6d. and 11s. 3d. The crop of 1909 was a poor one, and prices rose till August, 1910, when they began to fall down to 8s. 9d. in October, remaining below 10s. till March, 1911, when fears of another bad crop, which eventually showed a deficiency of 1,800,000 tons, caused an inevitable and very serious rise. In 1912, prices fell to 9s. and in 1913 below 9s., and ranged between 9s. and 10s. until the war came.

This is a reply to those who try to make people believe, and to those who so readily did believe, that prices were high owing to the abolition of the bounties. They can now see that during the period 1903–14 prices were generally below or round about the cost of production. The high prices were, therefore, caused by the bounties, not by their abolition.

XII.—NOTES ON SUGAR BEETROOT GROWING IN THE
UNITED KINGDOM, FROM THE
MINISTRY OF AGRICULTURE'S REPORT

The area given to the cultivation of sugar beetroots during 1930 was 347,257 acres, representing an increase of 51 per cent. over 1929, the previous highest; 63 per cent. of this acreage was in Lincolnshire, Norfolk, Suffolk, and Isle of Ely. The increase was chiefly due to the good result of the 1929 crop and to the fact that other crops were of abnormally low value: 40,000 growers contributed, and 17 factories worked up the roots into sugar in England and one (Cupar) in Scotland. The average yield per acre in 1930 was 8·8 tons of roots, against 8·7 in 1929 and 7·7 in 1928, but the sugar content was 16·74, against 17·69 in 1929 and 17·38 in 1928, the drop being due to the weather. The price received for roots averaged 49s. 10d., whereas 52s. 11d. was paid in 1929 and 51s. 11d. in 1928. The campaign lasted on average 115 days, due to the heavy crop, the two previous campaigns having lasted 91 and 74 days. One and a quarter tons of sugar were produced per acre of roots, a reduction of 4 per cent. on 1929. This indicated good factory work, considering the greater reduction in the sugar contained in the roots. Although the crop was somewhat disappointing, due to unsuitable weather, it was observed that there was distinct improvement in the manner in which the roots were grown and handled. The statistics on the following page give an indication of the growth of the industry and the factories contributing thereto.

Season	Acres	No. of Factories	Production of Sugar	Production of Commercial Sugar per Acre of Beet Grown
			In Tons	In Lbs.
1924-25 .	22,441	3	23,915	2,387
1925-26 .	54,470	8	51,638	2,113
1926-27 .	125,814	12	150,196	2,674
1927-28 .	222,566	17	182,581	1,878
1928-29 .	175,734	18	193,783	2,469
1929-30 .	229,918	18	291,500	2,837
1930-31 .	347,257	17	422,728	2,724
1931-32 .	234,400	17	291,000	—

Factory	Washed and Topped Beet Delivered to Factory		Rated Beet Slicing Capacity per Campaign of 100 days
	1929	1930	
1. Allscott . . .	114,104	140,909	85,000
2. Bardney . . .	99,493	166,153	100,000
3. Brigg	64,122	122,361	70,000
4. Bury St. Edmunds .	208,810	324,529	200,000
5. Cantley	229,330	310,492	250,000
6. Colwick	92,741	129,966	120,000
7. Ely	251,672	300,068	250,000
8. Felstead	75,872	149,440	120,000
9. Ipswich	126,154	172,678	145,000
10. Kelham	55,913	96,394	100,000
11. Kidderminster . .	94,561	130,817	120,000
12. Kings Lynn . . .	137,420	184,358	120,000
13. Peterborough . .	114,024	256,454	180,000
14. Poppleton	54,053	123,653	120,000
15. Selby	87,613	113,458	100,000
16. Spalding	90,275	149,995	120,000
17. Wissington . . .	84,412	117,743	100,000
18. Eynsham	18,956	dismantled	—
TOTAL	1,999,525	2,989,468	2,300,000
Cupar	—	59,859	—
GRAND TOTAL . . .	1,999,525	3,049,327	2,300,000

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